# Journal of SOIL and WATER CONSERVATION

**Volume 9, No. 6 November, 1954**

**Estimates of Wind Erodibility of Field Surfaces**
. . . W. S. Chepil and N. P. Woodruff

**Use of Aircraft in Soil Mapping**
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**Irrigating and Reclaming Desert Land in Peru**
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**Soil Erosion Survey of Latin America—Part III**
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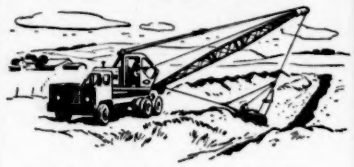

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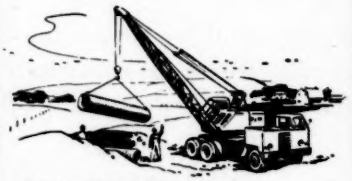

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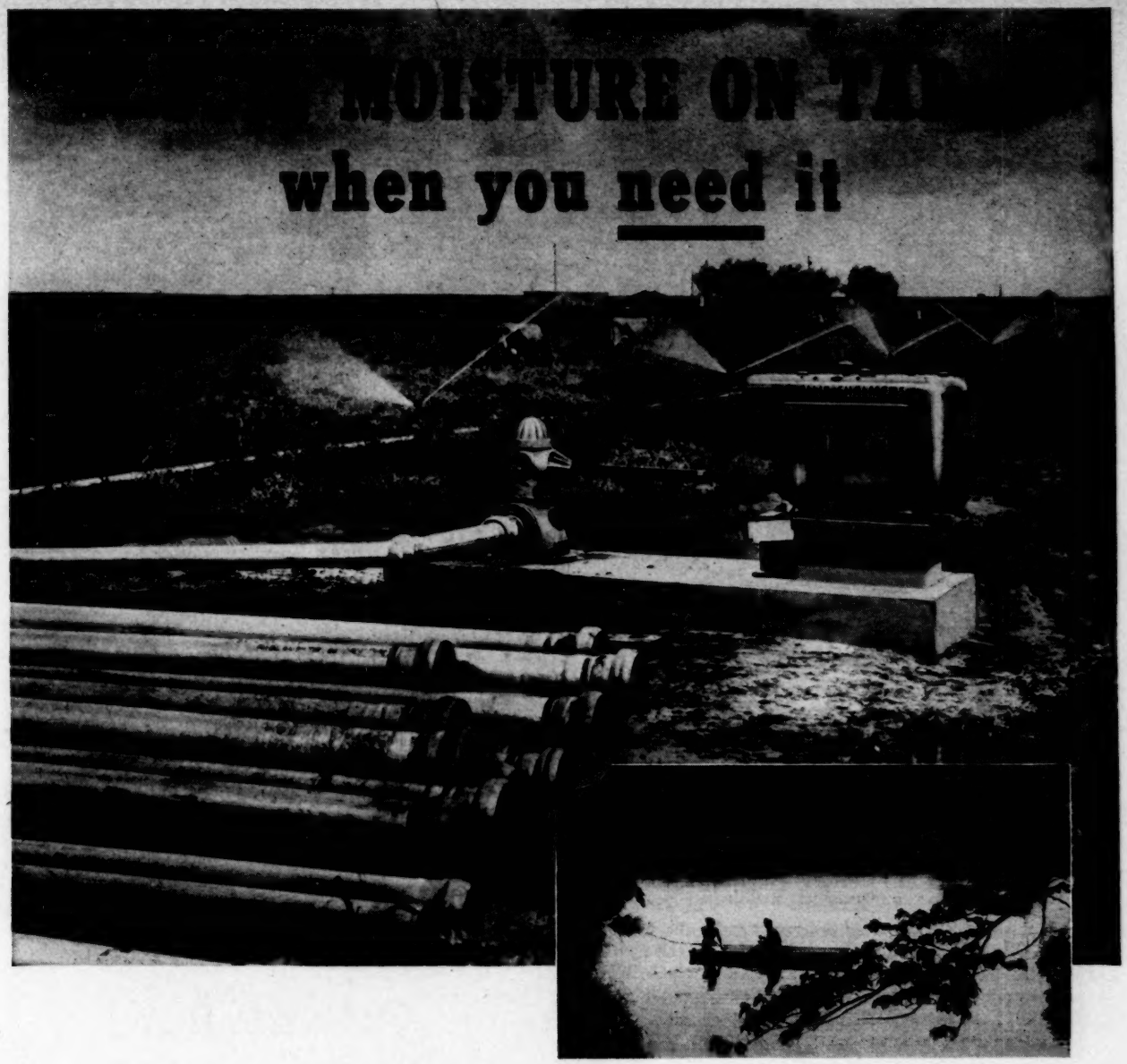


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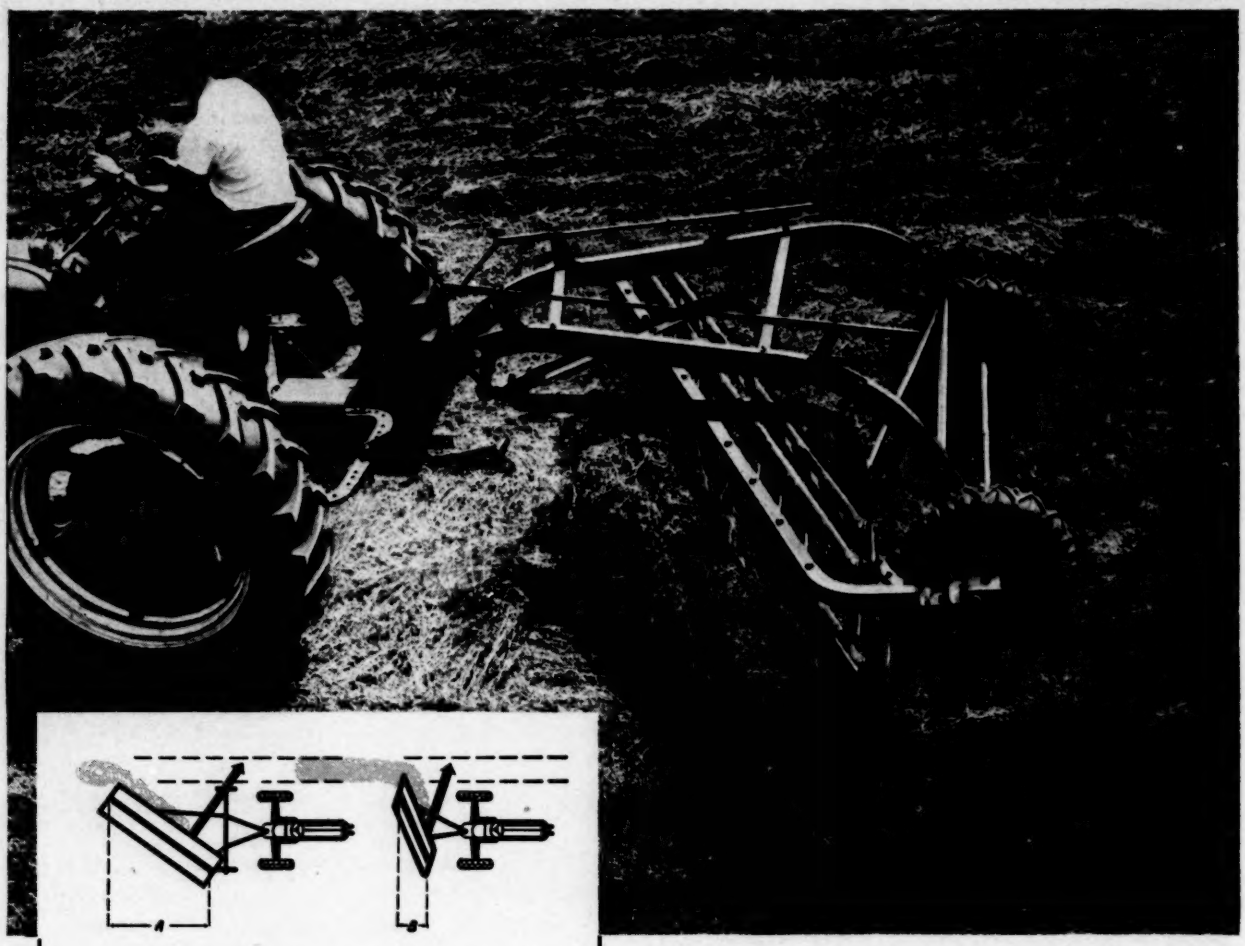



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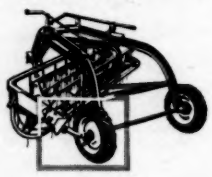

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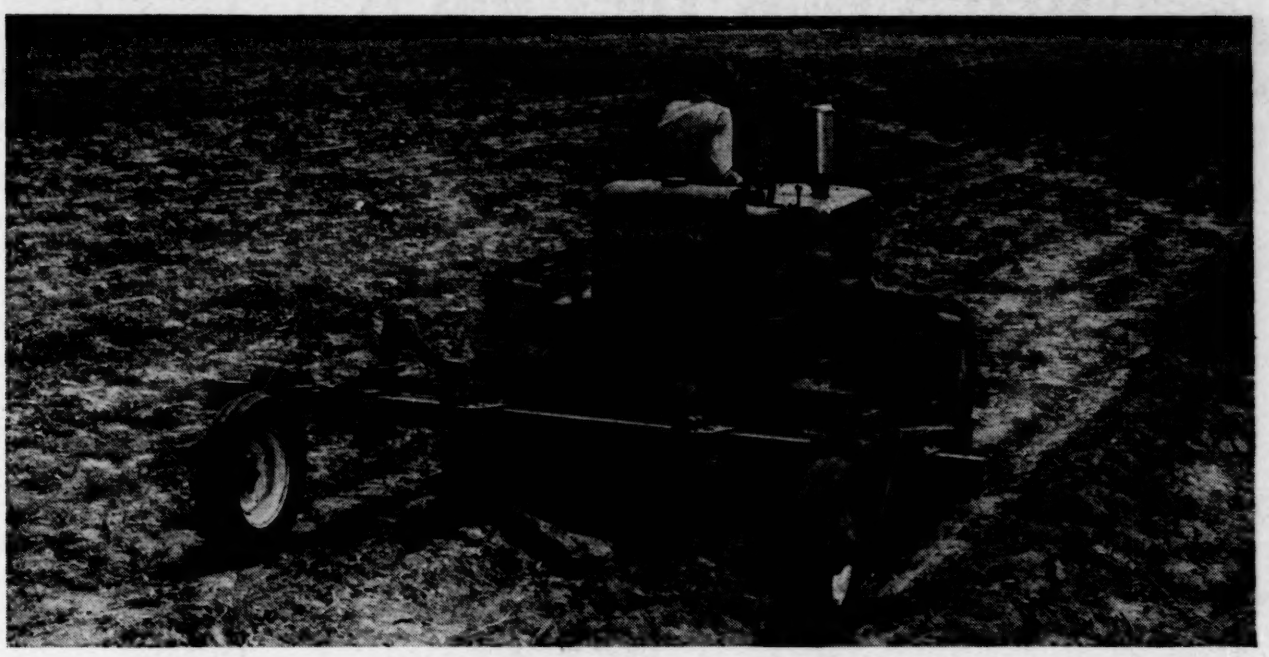

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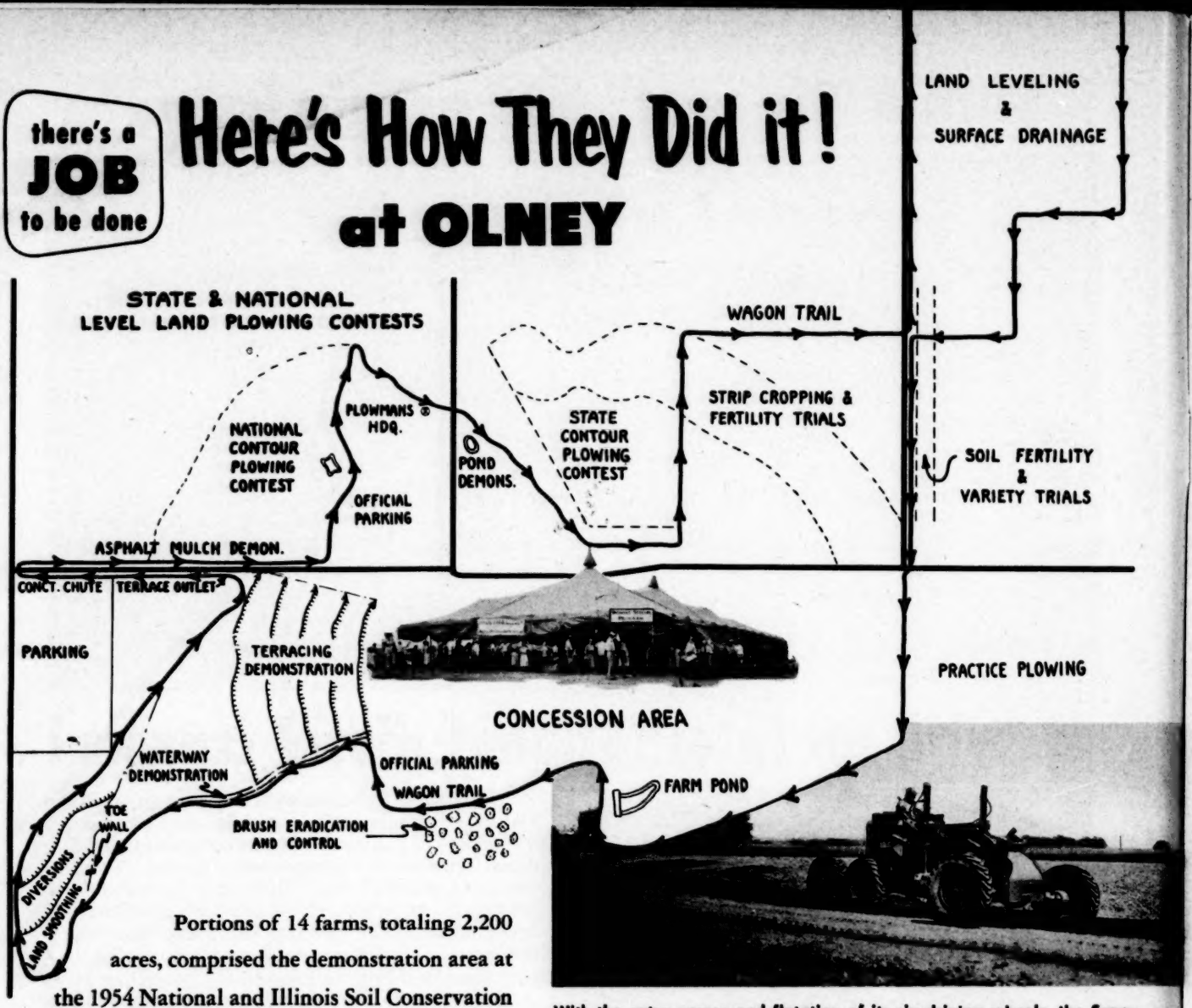


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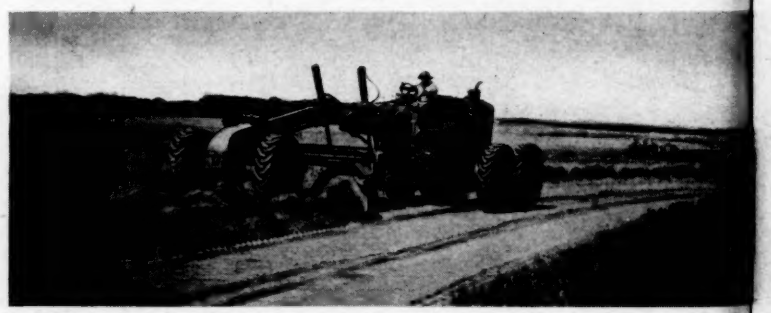

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***COVER—This close-up of a fine stand of Ladino clover and Kentucky 31 fescue grass represents one of the new combinations of clovers and grasses introduced as a result of the efforts of the conservation movement.***


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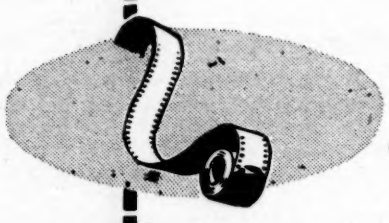

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# The Problem Area as a Basis For Developing a Soil Erosion Map

JOHN S. McVICKAR

***Because of the importance of wind and water erosion in Michigan, it seemed desirable to have a map showing the incidence of such erosion in sufficient detail to give an adequate perspective of the needed control requirements. To accomplish this, a sampling survey method was employed to utilize existing bases in evaluating and delineating the erosion situation in the state. The proceedings developed were successful and can be made applicable, according to the author, to other parts of the region and the United States, provided regional variations in character of farming, farmers, climate, land, soil and vegetation are taken into account.***

OLD RECONNAISSANCE soil erosion surveys and present detailed soil surveys show that wind and water erosion are widespread in Michigan. A soil erosion map of Michigan with sufficient detail to indicate where the chief emphasis on erosion control should be placed has not been prepared.

The purpose of this research project was to develop a method which will give an appraisal of the present erosion situation and present the information in the form of a state erosion map. The problem area (*unit resource area*), which is utilized by the Soil Conservation Districts in broad program planning, was used as a basis for this study. A problem area refers to a land unit where the associated soil, drainage, slope, erosion, and soil conservation problems are essentially the same. Generally the broad delineations of a problem area are the result of consultations between soil science personnel of the Soil Conservation Service and of the Land Grant Colleges and or other state level officials of comparable status, familiar with the land pattern and soils of a given area.

## Methods Used in Conducting Study

A sampling procedure was designed to determine the kind and degree of erosion in Michigan by problem areas. The procedure was designed to utilize data already available from field sheets in the files of the Soil Conservation Service to eliminate additional field survey work. The method employs a small sample technique with the best distribution possible from the detailed soil survey maps of individual farms in a given problem area. It also strives for the best distribution of samples among the land areas that have been mapped by the soil scientists of the Soil Conservation Service for a particular problem area (Figure 1). The sampled acreage involved was just slightly more than two per cent of the total land area in each problem area. The detailed soil survey maps which included the selected samples from each problem area were reproduced by the Soil Conservation Service on uniform single weight photographic paper suitable for cutting and weighing on a sensitive balance (Figure 2). Acreages were determined according to soil type, slope, erosion, and land use (Figure 3).

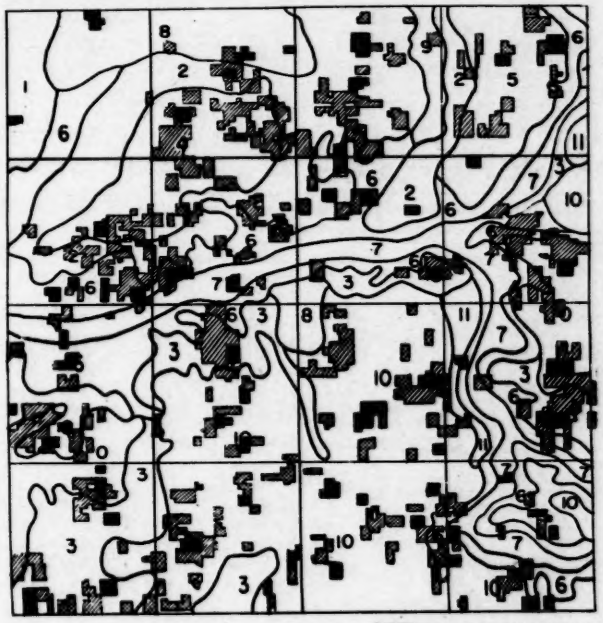


Figure 1. Distribution of farm soil survey maps available for each problem in X Soil Conservation District.

Soil erosion data obtained by using this technique in two widely separated soil conservation districts were compared with the data obtained from complete coverage. The following table shows the similarity of the data obtained by the two methods.

On the basis of these comparisons the procedure was considered of sufficient reliability to apply it to other problem areas in other soil conservation districts in Michigan.

Only a summary of erosion determination was made on the problem area data, although it is anticipated that

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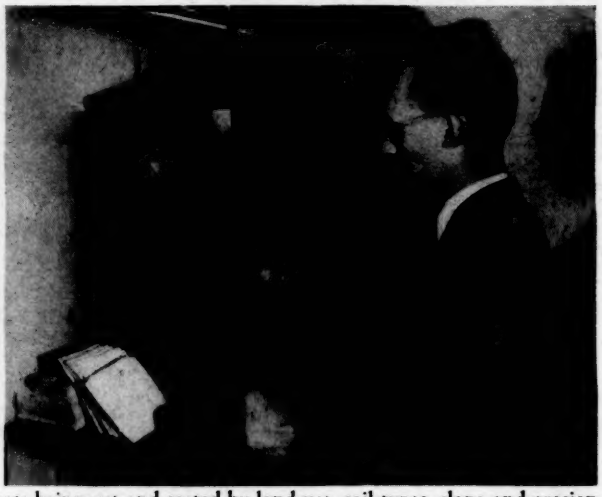

Figure 2. *Left.* Photographic reproductions of original field sheets being cut and sorted by land use, soil types, slope and erosion delineations. *Right.* Weighing the sorted segments on a sensitive balance.

**Table One. Comparison of Sampling Procedure with Complete Mapping for Determination of Soil Erosion**

| *Fenton Soil Conservation District* | | |
|---|---|---|
| Erosion Class | By Sampling Technique | By Complete Mapping |
| None to slight | 81,160 acres | 75,700 acres |
| Moderate | 26,989 acres | 34,689 acres |
| Severe | 9,205 acres | 7,638 acres |
| Very severe | 1,791 acres | 1,085 acres |
| Very severely gullied | 362 acres | 395 acres |
| *Muskegon Soil Conservation Districts* | | |
| Erosion Class | By Sampling Technique | By Complete Mapping |
| None to slight | 190,029 acres | 199,362 acres |
| Moderate | 63,713 acres | 63,622 acres |
| Severe | 28,530 acres | 20,632 acres |
| Very severe | 13,450 acres | 11,412 acres |
| Very severely gullied | 7,960 acres | 8,654 acres |

additional studies involving multiple correlation of erosion and use, soil type, and slope will be made from the data collected. The erosion information was measured and summarized on a percentage basis for these erosion class groups: None to slight; moderately severe; severe; very severe; and very severely gullied land. These erosion class groups are essentially those of the *Soil Conservation Survey Handbook* (1).

## Discussion and Interpretation of Data

Accelerated erosion is the movement of soil by natural agencies such as wind and water resulting from changes in the natural cover or ground conditions. In sheet erosion a more or less uniform thin layer of surface soil is removed by water. It is usually accomplished by the formation of tiny rills that are smoothed out by the next cultivation. However, if the channels are too deep to be smoothed out by cultivation, gullies result. Wind erosion includes both removal of soil and accumulations blown onto land. The degree of erosion in any case is estimated in relation to the original land surface.

According to the *Soil Conservation Survey Handbook* two results of water erosion are: Removals, or erosion proper; and accumulations resulting from removals on some other area. Removals include both sheet and gully erosion. Sheet erosion groups are: Class 1.—less than 25 per cent of the topsoil removed; class 2.—25 to 75 per cent of the topsoil removed; class 3.—75 per cent or more of the topsoil removed, or all of the topsoil and less than 25 per cent of the subsoil removed; class 4.—all the topsoil and 25 to 75 per cent of the subsoil removed; and class 5.—all the topsoil and 75 per cent or more of the subsoil removed (parent material may be eroded). Three classes of gullies are recognized: (1) Occasional gullies, more than 100 feet apart; (2) frequent gullies occurring

| SOIL-SLOPE EROSION | WT. | ACRES | PRESENT LAND USE | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | P | F | X | H | U | |
| 32-A-0 | 0.010 | 4.0 | | | F | | | | |
| 32-A-1 | 0.002 | 0.8 | | P | | | | | |
| 32-A-1 | 0.021 | 8.4 | L | | | | | | |
| 44-A-1 | 0.089 | 35.6 | L | | | | | | |
| 44-A-1 | 0.001 | 0.4 | | | F | | | | |
| 44-A-1 | 0.048 | 19.2 | | P | | | | | |
| 44-A-1 | 0.005 | 2.0 | | | | | H | | |
| 45-C-2 | 0.001 | 0.4 | | | | X | | | |
| 060-A-0 | 0013 | 5.2 | L | | | | U | | |
| | | | | | | | | | |
| | | | | | | | | | |

Figure 3. Method of recording data according to soil type, slope, erosion, and land use.

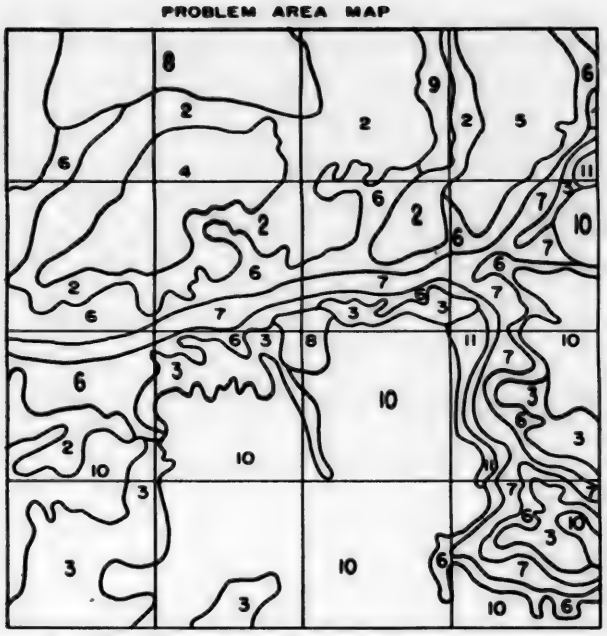


Figure 4. Soil Conservation District showing problem areas as delineated by The Soil Conservation Service.

less than 100 feet apart but affecting less than 75 per cent of the area delineated; and (3) very frequent or large gullies. Three classes of gullies with respect to depth and crossability are recognized.

For purposes of uniformity the criteria used by Soil Conservation Service soil scientists in appraising erosion during field mapping were necessarily those of the *Soil Conservation Survey Handbook*. This resulted in a good appraisal of the general erosion picture in Michigan. The modification of these erosion class groupings (2) gave a clearer picture of the erosion situation for that part of Michigan covered by this investigation. A still clearer picture of the erosion situation in Michigan may be obtained by using the classification outlined in Table 2.

Except for those areas where wind erosion was a major problem, it was impractical to attempt to separate wind and water erosion by the sampling technique, hence these types of erosion were not reported independently.

**Table Two. Erosion Classification Used in Study**

| | |
|---|---|
| Class I | 90-99 per cent none to slight erosion<br>1-10 per cent moderately severe erosion |
| Class II | 80-90 per cent none to slight erosion<br>10-20 per cent moderately severe erosion |
| Class III | 60-80 per cent none to slight erosion<br>20-30 per cent moderately severe erosion; not over 10 per cent severe and very severe erosion |
| Class IV | 50-60 per cent none to slight erosion<br>40-50 per cent moderately severe erosion; very small amounts of severe and very severe erosion |
| Class V | 50-60 per cent none to slight erosion<br>20-30 per cent moderately severe erosion; 1-10 per cent severe, very severe, and severely gullied erosion |

An erosion map of X Soil Conservation District (Figure 5) was drafted from the erosion data listed in Table Three, using the classification shown above.

The sampling procedure reported may be somewhat selective unless the Soil Conservation cooperators are well

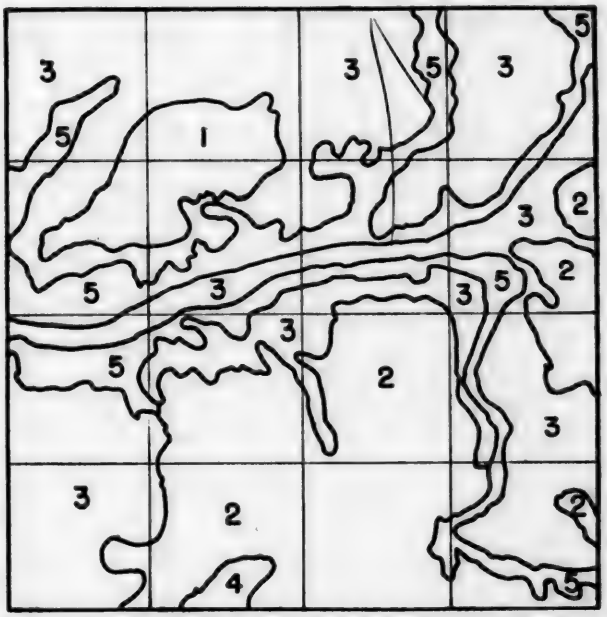

Figure 5. An erosion map of X Soil Conservation District based on soil conservation problem areas and percents of erosion as shown in Table 3.

**Table Three. Percentages of Erosion by Classes in Problem Areas in X Soil Conservation District**

| Problem Area | % Class 1 Erosion | % Class 2 Erosion | % Class 3 Erosion | % Class 4 Erosion | % Class 5 Erosion | % Unclassified Erosion |
|---|---|---|---|---|---|---|
| 1. Rolling to steep loams | 19.1 | 61.5 | 14.7 | 1.6 | — | 3.2 |
| 2. Undulating to rolling clay land | 47.8 | 40.3 | 9.1 | 0.9 | — | 2.0 |
| 3. Rolling clay land | 61.7 | 31.2 | 4.7 | 0.1 | — | 0.4 |
| 4. Level, dark colored med. to light tex. soils | 87.3 | 9.5 | 1.0 | — | — | 2.1 |
| 5. Level to undulating loams imperfectly to well drained | 61.8 | 17.8 | 17.8 | — | — | 2.6 |
| 6. Steep, sandy gravelly hills | 35.3 | 49.0 | 12.3 | 1.1 | 0.8 | 1.6 |
| 7. Alluvial and valley soils | 69.8 | 22.4 | 3.4 | 0.8 | — | 3.7 |
| 8. Level to pitted light well drained soils | 60.2 | 33.6 | 3.0 | 1.4 | — | 1.8 |
| 9. Level, dark colored sandy gravelly plain | 95.5 | 2.6 | 1.9 | — | — | — |
| 10. Undulated clay land | 78.0 | 19.6 | 0.3 | — | — | 2.2 |
| 11. Level to steep, light, mod. rapid permeability | 60.7 | 36.7 | 0.9 | — | — | 1.7 |

distributed over a problem area, or if they represent the better farmers of the area. The possibility of taking a truly randomized sample is pre-cluded by the fact that the land has not been mapped solidly by the soil scientists of the Soil Conservation Service. To be highly accurate the sampling procedure should be supplemented by field observations and field checking in those particular problem areas.

### Summary

By analysis of the accumulated data in an area or state, the distribution of erosion can be determined. The method reported offers a fairly quick and economical means of appraising the overall erosion for a region and this permits the emphasis on erosion control to go where it is most needed. It is felt that the procedure can be made applicable to other parts of the region and the United States taking into account regional variations in the character of farming, farmers, climate, land, soil and vegetation.

By extrapolation of data collected in problem areas mapped to like problem areas not mapped, the method can provide a basis for determining the magnitude of the conservation needs resulting from erosion to be met in different problem areas of the state.

A new state-wide erosion map will be drafted to give a real expression to the results obtained from the study.

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# Use of Aircraft in Soil Mapping

R. BROWN and R. S. FARNHAM

***Soil mapping has improved considerably since the days of the "horse and buggy" surveys. Plane tables have been discarded in favor of aerial photographs, new techniques have been developed, costs reduced and much time saved. In spite of this, there is a tremendous survey job ahead. The need for developing new techniques to greatly accelerate the survey job is recognized. Use of aircraft in suitable areas might conceivably help fulfill this need. Results of preliminary studies reported in this article indicate the method to be reasonably accurate, very fast, and inexpensive; also very successful in certain areas.***

IN SEVERAL STATES, the light airplane has been used effectively in various soil conservation activities. It has become very useful in the study of watershed, forestry, grazing, and erosion problems and conditions in large areas. In soil conservation education, "soil conservation air tours" have graphically presented the story of our land to thousands of people. The airplane's use in the everyday work of the soil scientist has not been fully explored, however, it probably offers many advantages. A relatively new approach to soil survey is involved and there is much to be learned concerning its practical application.

Currently, two methods are commonly employed in mapping soils. One is the conventional ground method, using aerial photographs. The other is the stereoscopic method, utilizing pairs of aerial photographs and a stereoscope. To these may be added a third, the airplane method. The ground method has the advantage over the other two in that the soil can be examined in the field *in situ*.

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In many respects, the stereoscopic and airplane methods are similar. Success with the stereoscopic method, however, depends almost entirely on the quality and accuracy of the aerial photographs. Poor photographs seriously affect the accuracy of the images obtained. On the other hand, the airplane method relies on the aerial photographs merely as an aid.

Features of the landscape which help in identifying soils from an airplane include slope, color tone, land form, vegetation, erosion, drainage pattern, and land use. With the exception of slope, these features are easily identified from the air.

From his "observation platform," the air mapper observes the features of the landscape which suggest certain soil patterns. Because of his knowledge of the relationships of the various environmental factors, he can identify the different soils and sketch their boundaries on his aerial photograph. It should be emphasized, however, that accurate interpretation from the air depends to a large extent upon the mapper's knowledge of ground conditions.

### Minnesota Tests

In an attempt to determine the effectiveness of aircraft in soil mapping, a number of tests were made in Minne-

sota in 1952 and 1953. They were conducted jointly by the Soil Conservation Service, Minnesota Agricultural Experiment Station, and the Minnesota Department of Aeronautics. Sample areas of about 2 square miles were selected in five widely separated counties. Several SCS soil scientists participated in the tests. Results in 1952 were far from conclusive, but a great deal was learned.

In 1953 it was decided that intensive tests would be made by only one mapper and one pilot. This was because insufficient time was available to allow several soil scientists to become fully proficient with the method. Accordingly, several 2-square-mile areas in Fillmore County, Minnesota, were mapped in May and early June by the authors of this report. The results, while inconclusive in some particulars, were very encouraging.

## Nature of the Area

The areas mapped are a relatively smooth glacial till plain of Iowan Age. This plain is characterized by long gentle slopes, frequent sink holes, large depressional areas, and an occasional sandy or gravelly knoll. The smooth surface is dissected in places by erosion, while in other places, sand has been deposited on the surface. The mantle of glacial till varies in thickness from a few inches to many feet, with the limestone bedrock exposed at some places. Where limestone is only a few feet below the surface, sink holes are numerous.

The principal soils of this area have been developed on glacial drift deposits under the varying influences of both tree and grass vegetation. Variations in the soils are primarily due to differences in the kind of parent material, native vegetation, drainage, and topography or lay of the land. The predominant upland soils are the light-colored (Gray-Brown Podzolic), and dark-colored (Prairie) soils which were developed from glacial drift.

## Results

These tests indicate that soil maps made from the air closely approximate the actual pattern of soils on the ground. The amount of detail obtained in most cases was less than could be gained with the conventional ground method. But where adequate ground checks were made, it was possible to obtain enough detail to fulfill most survey needs.

The principal criteria used by the mapper in distinguishing between the upland soils are the thickness and color of the surface horizon. The amount of light reflected by the surface is dependent upon the character and composition of the soils. The different color tones, which usually suggested the location of soil boundaries, were readily apparent to the observer in the airplane (Figure 1). Sand and gravel areas were easy to identify from the air, with the exception of those areas where the coarse material lay at a considerable depth below the surface. It was exteremly difficult to separate the normal upland soils from those shallow to limestone unless the presence of limestone was indicated by a series of sink-holes or by road-cut exposures.

*Photo by Soil Conservation Service*

Figure 1. Typical aerial view of a landscape showing various color tones which are indicative of certain ground features. Dark colors in foreground along upper drainageways are areas of wet soils. Light tones appearing as streaks are gullies; those on slopes between gullies indicate sheet erosion or sandy spots. Terraces in left foreground suggest a strong slope.

In general, slope separations were mapped from the air much better than had been anticipated. The nearly level area, 0 to 2 per cent slope, were accurately outlined in most cases. On more rolling areas, with slopes ranging from 5 to 12 per cent, the separations were mapped less accurately, but ground measurements with the Abney level showed them to vary only one to three percentage points from actual.

Flights were made at several different altitudes to determine which was most satisfactory for mapping. It was found that land use, drainage, and the general soil patterns could best be mapped at around 1,500 to 2,000 feet above the terrain. The areas being mapped could be seen for a longer time and the sketching was easier from those heights than from lower altitudes, where the speed of the plane was a limiting factor. Detailed soil and erosion separations, as shown in Figure 2, were best made from a height of 500 to 700 feet above the terrain, and slopes were best judged from this height and at a horizontal distance of from ½ to ¾ mile from the area being mapped.

Flights were also made in early and late spring over a deciduous forest area to evaluate further the effectiveness of the airplane method and to determine the best time of year to make soil maps of wooded areas. Results of these tests were very satisfactory; ground checks showed that wooded areas can be mapped from the air much faster and with a much greater degree of accuracy than on the

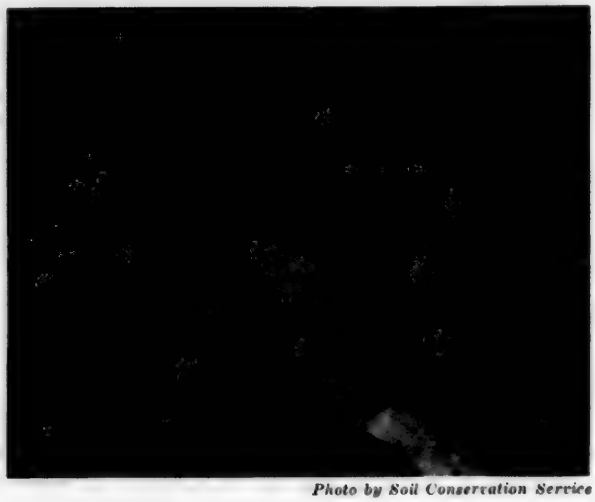


*Photo by Soil Conservation Service*

Figure 2. Aerial view from low altitude showing detailed soil, erosion, and land use features.

ground. Best results were obtained in early spring, before the foliage was on the trees.

Results of these tests suggest that, if a combination of airplane mapping and ground checking is employed, the following types of maps are possible:

(1) *Reconnaissance Maps.* One-half hour flying time and less than 30 minutes ground checking for each square mile (section) area.

(2) *Semi-detailed Maps.* One-half hour flying time and approximately 30 minutes to an hour ground checking for each square mile (section) area.

(3) *Detailed Maps.* One-half hour flying time and approximately 2 hours ground checking for each square mile (section) area.

With the aircraft used, a Fairchild 24, as many as six trips around and across each two-square-mile plot were found necessary. With slower moving aircraft of the highwing type, it should be possible to reduce the trips to about four. Flying time required for each plot averaged approximately one hour, including time from and to the airport, which was centrally located in the test area.

Attempts to map for periods much longer than an hour at a time proved fatiguing to both mapper and pilot. One of the most impressive facts learned is that both mapper and pilot must learn to use this method. The mapper must learn to identify soils and evaluate physical terrain features from an unaccustomed distance, and the pilot must learn how to keep his "observation platform" in the most advantageous position from the mapper's viewpoint.

## Points to Remember

Following are six pointers for soil mapping from the air:

1. *Time of year:* Best results can be obtained in the spring, after all snow has disappeared but before leaves of trees and vegetation become prominent enough to restrict visibility and before the crop plants have covered the ground in the fields.

2. *Weather:* We were surprised to learn that we obtained as good results working under an overcast as in bright sunshine. Turbulent air or very high winds are a serious handicap, however, so most of the tests were made between sunrise and 10:00 A.M. when air movement is generally at a minimum.

3. *Equipment:* As the airplane serves only as an elevated and mobile "observation platform," the prime requisites are slow speed and good downward visibility from the mapper's position. The Fairchild aircraft that was used could not be flown safely below 65 to 70 m.p.h. and it was found that this speed does not give the mapper sufficient time to observe details and sketch them on the aerial photo. Any light aircraft of the highwing type, which can be flown at 60 m.p.h. or less, would be satisfactory. Also, such an aircraft can be successfully operated from fields other than improved airports. The mapper needs only his map board and an ample supply of pencils. Obviously, a helicopter would have many advantages over the conventional light planes, but the high rental fee and expense of operation would be prohibitive.

4. *Height:* Land use, drainage and general classification of soil types can best be mapped at around 1,500 and 2,000 feet above the terrain: slope separations, detailed soil separations, and erosion can best be judged from a height of 500 to 700 feet and at a horizontal distance of ½ to ¾ mile from the area being mapped.

5. *Area:* Rectangular plots of two sections were chosen in order to reduce time lost in making turns, but it is believed that strips several miles long and 1 mile wide would be more practical if the photos can be handled conveniently.

6. *Teamwork:* The mapper and pilot should work together as a team insofar as practicable. One aircraft and pilot can probably keep two mappers busy, if working in the same area, by flying each alternately. Thus, one would be in the air mapping while the other made such ground checks as were necessary.

## Advantages of Air Mapping

It was apparent from these tests that mapping from the air may be particularly advantageous in certain areas and of doubtful value in others. Its worthiness depends to a large extent on the complexity of the soil pattern.

In suitable localities, this method shows promise in speeding up the mapping of soils. There are many places where the soil pattern is relatively simple due to the uni-

(*Continued on page 274*)

# Estimations of Wind Erodibility of Field Surfaces

W. S. CHEPIL AND N. P. WOODRUFF

***Three major factors influence erosion of soil by wind: surface roughness, vegetative cover, and degree of soil cloddiness. The authors indicate how these factors can be measured, how erodibility of a cultivated field surface can be determined, and what degree of surface roughness, vegetative cover, or soil cloddiness would be needed to reduce erosion to any degree. They believe that the guide presented in this paper can be used in helping the soil conservationist to determine what practices can or cannot be used to control wind erosion on different soils.***

THIS PAPER PRESENTS a method to estimate relative susceptibility of field surfaces to erosion by wind or, conversely, to evaluate the effectiveness of crop residues and tillage practices in reducing erosion. The method for estimating erodibility has been developed from results obtained principally with a portable wind tunnel and accessory equipment described in previous publications (7, 8).

Three major factors appear to govern the erodibility of a land surface. These are the dry soil structure, surface roughness, and crop residue on the soil surface. All three can be measured or estimated. There are, of course, other factors—perhaps the most important are surface barriers and the size, shape, and topographic layout of a field. Also, the presence or absence of a surface crust is an important factor; however, no technique has been found to measure it successfully. Despite such limitations, results of field studies have provided the background for making approximate estimates of erodibility of field surfaces from the three major factors. These estimates are tools for a better understanding of wind erosion and for determining more conclusively how it may be controlled best.

Some of the objectives and reasons for estimating the erodibility of farm fields are: (a) to determine probabilities of wind erosion in the near future or during the next windy season so that some warning may be given in advance, (b) to determine the degree of surface roughness and/or soil cloddiness required in an emergency control program to supplement the amount of vegetative cover available on the land, and (c) to determine effectiveness of crop residues and tillage practices in providing protection against wind for different soils and physical conditions of the soils.

*W. S. Chepil, soil scientist and N. P. Woodruff, agricultural engineer are associated with the Western Section of Soil and Water Management, Agricultural Research Service, U. S. Department of Agriculture. Both men are located at Manhattan, Kansas.*

*This paper is Contribution 504, Department of Agronomy, Kansas Agricultural Experiment Station, Manhattan and the U.S.D.A. Agricultural Research Service, Soil and Water Conservation Research Branch. Cooperative Research in the mechanics of wind erosion.*

*Grateful acknowledgement is made by the authors to A. W. Zingg for contributions to this study and for his part in developing and constructing a rotary hand sieve herein described.*

### Determining Surface Roughness

The rougher the surface the greater is its tendency to lower the surface velocity of the wind and to reduce the movement of soil by wind. The degree of surface roughness depends on height, length, density, and quality of vegetative cover and on size, shape, and lateral frequency of clods, ripples, and ridges. It is extremely difficult to determine surface roughness by measuring these surface obstructions. For this reason a "ridge roughness equivalent" based on the height of ridges composed of fine gravel 2 to 6.4 mm. in diameter and having a height-spacing ratio of 1:4 was devised. For example, if the ridge roughness equivalent is four inches, the surface has a roughness and resists wind to the same degree as gravel ridges four inches high and 16 inches apart at right-angles to the direction of the wind.

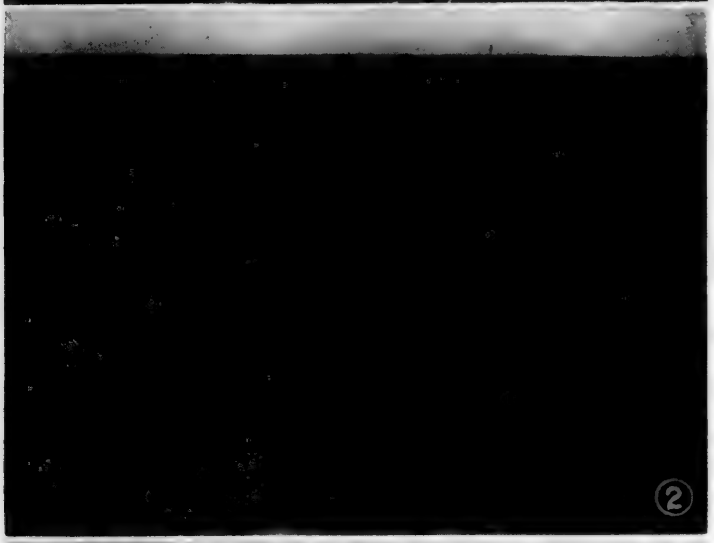
Measuring ridge roughness equivalents without a wind tunnel is virtually impossible, but estimates can be made with reasonable accuracy from photographs of different field roughness for which the ridge roughness equivalent is known. Photographs have served as a standard guide for visual estimation of ridge roughness equivalent of field surfaces. These standard photographs are given in figure 1 with a number beside each photograph referring to ridge roughness equivalent, designated by K, in inches. The amount of crop residue, R, above the surface of the ground also is indicated as supplementary data in each case.

Figure 1.—Guide for visual estimation of ridge roughness equivalent of field surfaces with the aid of 18 photographs. The ridge roughness equivalent K is in inches. The amount of crop residue R above the surface of the ground is in pounds per acre. The photos are shown on the following six pages.

K = 1.0 inch

Loose blowing sand virtually bare and smooth.

R = 312 lbs./acre




K = 1.5 inches

Smooth fallow surface beaten down by rain, virtually bare.

R = 224 lbs./acre

K = 1.6 inches

Good wheat residue cover, flattened down with one-way disc.

R = 425 lbs./acre

K = 2.0 inches

Loose surface of loamy sand with some grass.

R = 311 lbs./acre

K = 2.0 inches

Smooth surface with very sparse sorghum stubble.

R = 400 lbs./acre

K = 2.5 inches

Smooth surface with very short, thin sorghum stubble.

R = 245 lbs./acre

K = 2.6 inches

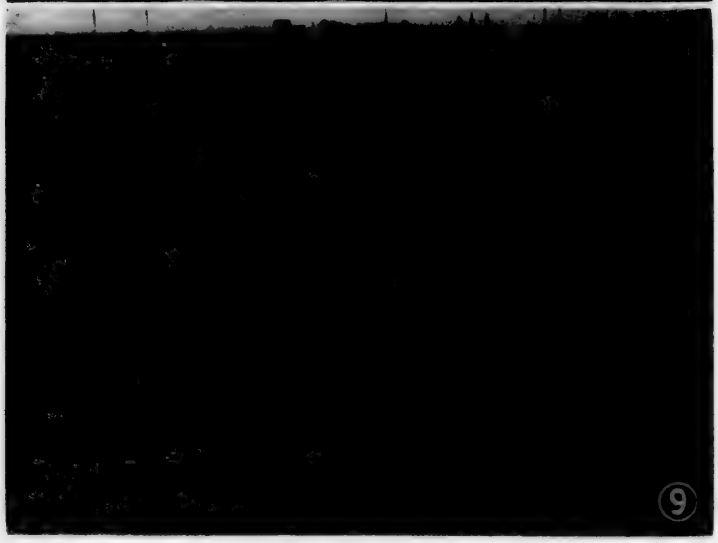
Semi-deep furrow drill ridges with some wheat stubble.

R = 790 lbs./acre

K = 3.2 inches

Good stand of growing wheat about 3.5 inches high, slightly ridged by drill.

R = 779 lbs./acre



K = 4.0 inches

Heavy combine wheat stubble partly flattened by one-way disc.

R = 3,980 lbs./acre

K = 4.0 inches

Recently plowed land, cloddy and moderately rough surface.

R = 100 lbs./acre

K = 4.3 inches

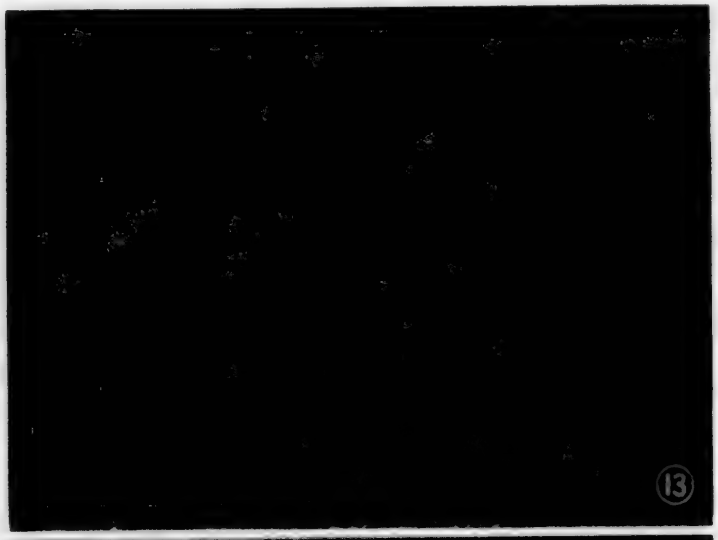
Cotton, machine stripped.

R = 1,090 lbs./acre

K = 4.35 inches

Sorghum stubble cut with binder 5 to 7 inches high, 40-inch rows.

R = 575 lbs./acre




K = 4.4 inches

Wheat stubble combined 8 to 10 inches high.

R = 1,090 lbs./acre

K = 4.6 inches

Chiseled sorghum stubble with some large clods; considerable drifting.

R = 640 lbs./acre

K = 6.3 inches

Sorghum combined 10 to 12 inches high, 40-inch rows.

R = 1,220 lbs./acre

K = 8.5 inches

Heavy sorghum stubble (on irrigated land), thick and leafy, cut 8 to 10 inches high, 40-inch rows.

R = 1,890 lbs./acre

K = 10.1 inches

Listed, with little or no residue on top.

R = 155 lbs./acre

K = 12.5 inches

Irrigated milo combined for grain, leaving 16- to 18-inch stubble as shown on extreme right. Rest of photo is irrelevant.

R = 2,275 lbs./acre

Figure 2.—Rotary hand sieve for use in the field. The cylindrical sieve is 20 inches long and 8 inches in diameter mounted eccentrically on a crank rod resting on a support base. The sieve has square openings 0.84 mm. in diameter. One-half inch metal screen is wrapped around it for support.

### Determining Crop Residue

Three one-square meter samples of crop residue selected at random appear sufficient in most cases to represent an average amount over the land. The residue on or above the surface is raked or cut off level with the ground and together with whatever soil may cling to it is placed in a tray or sack and labeled. The residue is brought to the laboratory, washed thoroughly on a 1.68 mm. screen, dried in an oven, and weighed. The weights are then expressed in pounds per acre.

It is believed that, where facilities are lacking, the amounts of residue may be estimated visually in a manner similar to that used for determining the ridge roughness equivalent. Standard photographs indicating different amounts and kinds of crop residue would facilitate the estimates.

### Determining Soil Cloddiness

A nonerodible soil fraction greater than 0.84 mm. in diameter, as determined by dry sieving, has been used successfully as an indicator of erodibility of soil by wind (1, 6). Although this fraction is not the only factor that influences erodibility, it is by far the most important. A technique for sampling the soil and sieving it on an automatic rotary sieve has been described previously (2, 3).

A simple hand-rotating sieve, such as that shown in figure 2, may be used conveniently in the field. The results of seiving depend somewhat on soil moisture, size of sample, speed of turning, and number of turns. These factors must remain constant if results of sieving are to remain comparable to those obtained with the automatic rotary sieve. The following conditions are adhered to when using the hand-rotating sieve:

1. The soil is sieved only when it is reasonably dry. If not dry, the soil may be brought into the laboratory, dried, and then sieved.
2. The soil to be sieved is taken down to the same depth in all comparable cases. For estimating erodibility, a layer from surface about 1 inch deep is taken.
3. Weight of sample sieved is four pounds (1,812 grams).
4. Speed of turning is two turns per five seconds. The speed can be gauged by keeping an eye on the second hand of a watch while turning.
5. The number of turns for sand, loamy sand, and sandy loam is five; for loam, silt loam, clay loam, and silty clay loam, ten; for silty clay and clay, 15.

The soil remaining in the sieve is weighed and expressed in percentage of total weight of soil.

### Determining Erodibility or Conditions Required to Prevent Erosion

Field studies during the past five years to evaluate erodibility of farm fields (4, 5, 9, 10) have indicated the following average relationship:

$$X = 491.3 \frac{I}{(RK)^{0.835}}$$

where $X$ = amount of erosion in tons per acre.
$I$ = soil erodibility index based on percentage of surface material greater than 0.84 mm. in diameter.
$R$ = amount of crop residue in pounds per acre.
$K$ = ridge roughness equivalent in inches.

The alignment chart shown in figure 3 permits a convenient graphical solution of this equation and is all that is required for estimating soil erodibility from determined conditions of soil cloddiness, surface roughness, and crop residue. Values of I are replaced by corresponding percentages of nonerodible soil fractions (table 2 of reference 4). Erodibility is read from the chart as follows: A straightedge is passed through the percentage value of nonerodible fraction greater than 0.84 mm. on line AB and through the value of RK (the product of residue in pounds per acre and ridge roughness equivalent in inches) on line EF. The erodibility value corresponding to these conditions lies at the point where the straightedge crosses line CD. Thus, let it be assumed that the proportion of nonerodible soil fraction is 17 per cent and the product RK is 1,500; then erodibility read from line CD is 4.5 tons per acre. This example is shown by a dotted line in figure 3.

The alignment chart can be used similarly to determine the effect of given amounts of residue in reducing erosion. The procedure for doing this would be to determine the nonerodible fractions by sieving, measure the amount of residue already on the field, then apply a given amount of additional residue and determine the ridge-roughness K from the photographs. For example, assume a field has a soil surface containing 17 per cent nonerodible fractions, 200 pounds of residue per acre, and a ridge roughness equivalent of 2.0 inches. The alignment chart shows the erodibility to be 14 tons per acre. Now further assume that 1,800 pounds per acre

of residue is applied to the surface of this same field, making a total residue amount of 2,000 pounds per acre which increases the ridge roughness equivalent to 5.0 inches. The alignment chart now shows the erodibility to be 0.9 ton per acre, which is a substantial reduction from the original condition. The effectiveness of stubble and other crop residue grown on the land could be measured in the same manner.

The alignment chart may also be used to measure the effectiveness of tillage practices, such as listing or chiseling to provide protection from the wind. The procedure in this case would be to carry out the practice, determine the percentage of nonerodible fractions in the worked soil, measure the residue, estimate K, and thus determine the erodibility from the chart. If a previous estimate had been made before working, the effect of the tillage could be evaluated. For example, assume a soil with a ridge roughness equivalent of 1.0 inch, a residue amount of 200 pounds per acre, and 17 per cent nonerodible fraction. The erodibility as determined from the chart would be 25 tons per acre. Let us assume that this same soil is worked with a lister and it increases the nonerodible fraction to 52 per cent, increases the ridge roughness to 10 inches, and buries 100 pounds per acre of residue leaving only 100 pounds per acre. The chart now shows the erodibility to be 0.25 ton per acre; thus, the lister through the process of increasing the nonerodible fractions and increasing the surface roughness has reduced the erodibility from a very high amount to an insignificant amount.

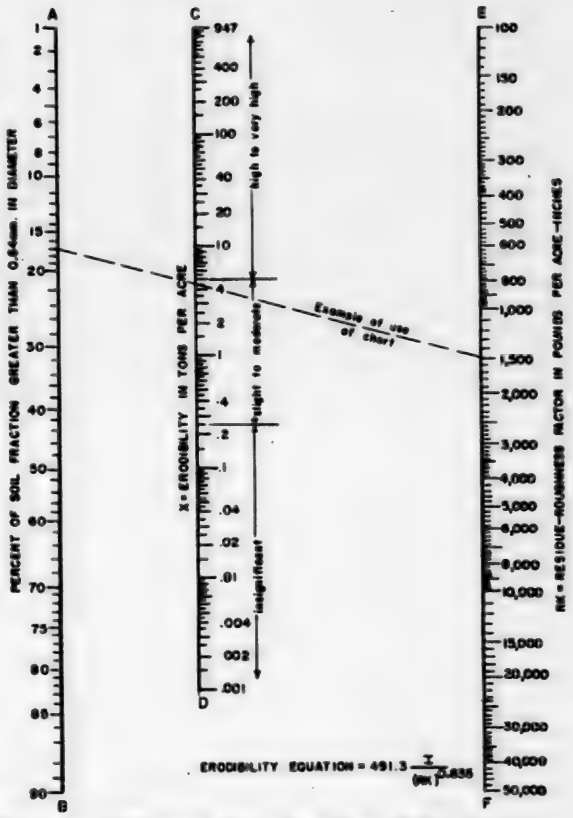



Figure 3.—Allignment chart for soil erodibility by wind.

### Interpretation and Limitation of Estimations

A wind erosion classification based on the relative erodibility values of figure 3 may be made as follows:

| Erodibility value | Erodibility | Basis of classification |
|---|---|---|
| < 0.25 | Insignificant | Soil is sufficiently protected by clods, ridges, or vegetative cover to make it essentially nonerodible. |
| 0.25 to 5.0 | Slight to moderate | Soil is only partly protected from erosion. |
| > 5.0 | High to very high | Soil is highly erodible and its surface is virtually unprotected from wind. |

Erodibility values of figure 3 serve merely as a relative measure of wind erosion. A tunnel different from the one on which these erodibility values are based, no doubt, would produce different amounts of erosion even under apparently the same wind force. The measured amounts of erosion are based on a drag of 3,000 pounds per acre. Relative values of erodibility would change little if a different drag were used. The amount of soil eroded under the same atmospheric wind force in the field also varies, depending on dimensions of the field, geographic location, and many other factors. Consequently, the actual amounts of soil moved by wind in a tunnel or in the field have little significance unless all the conditions that influence erosion are specified.

The present estimations are based on average results obtained from tests on some 88 farm fields covering a wide range of soil textures, soil surface conditions, and residue amounts. They are applicable to fields having roughness, residue, and cloddiness falling within the limits shown on the alignment chart. These conditions can be evaluated by procedures outlined in this paper. Some field experience might be necessary for making reliable estimations of these conditions, especially where visual estimations are used.

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(*Continued on page 285*)

# Irrigating and Reclaiming Desert Land in Peru

LUIS DE ARMERO GARCIA AND RENATO ROSSI

***This is the story of Peru's effort in reclaiming and irrigating unproductive lands, as told by two men who have played important roles in this movement.***

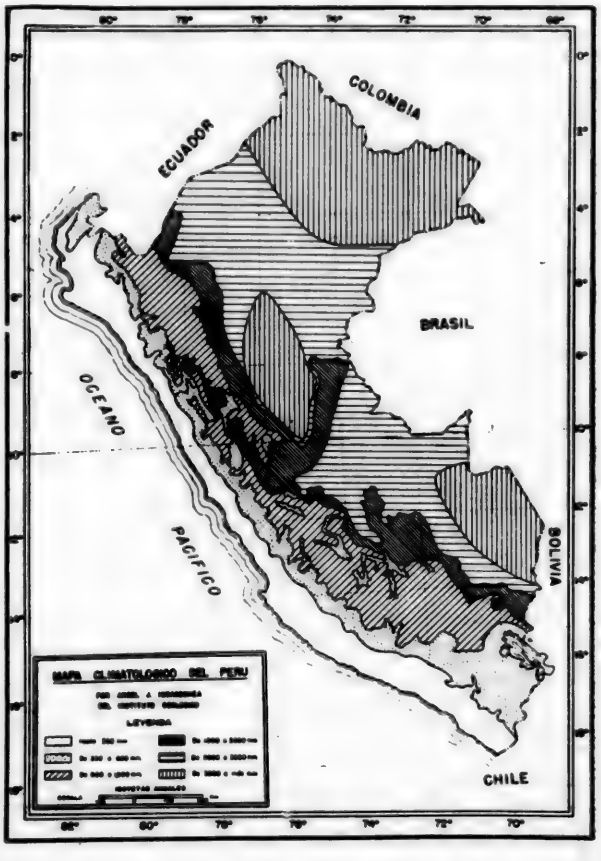
***The program generally recognizes the elimination of desert vegetation and other barriers; also land levelling and the construction of irrigation and drainage ditches. In addition, the authors point out steps that are being taken in the management and use of crops produced on these irrigated lands.***

IRRIGATION OF DESERT land in Peru is as old as its history. About 1,000 years ago, the Empire of the Incas had a well-developed policy of irrigation covering practically the same areas now under irrigation. We have also found the remains of irrigation canals in sections now in desert. This fact makes one think that the Incas had irrigation projects under way on many of the pampas which are now arid. It is probable that they interrupted their work upon the arrival of the Spaniards to whom gold meant more than agriculture.

The Colonial system of water distribution handicapped the development of irrigation. Only after the formation of the Republic (1821) and especially on the basis of new water legislation in 1898, we began to bring into use new desert areas through irrigation for agricultural purposes; 250,000 hectares were under irrigation along the coast at that time. This figure now totals over 500,000 hectares—an increase of more than 100 per cent. Of that increase more than 30,000 hectares were due to the efforts of private enterprise. The remainder was done by the Government.

The responsibility for the delay in initiating new irrigation projects in the Republic lay in the idea that arid regions far from the direct action of river water were sandy, saline, poor, unproductive and without any value. Lately this concept is disappearing and sometimes even exaggerated toward the opposite limit, considering any land good for irrigation provided there is enough water, even though the land be stony, very saline, and poorly drained, with the logical consequences of economic failure. But on the basis of the initial failure of the pioneers comes the benefit for those who follow, as in the case of the hungry man who arrives when the table is set. First farmers, through imperfect methods which brought failure and losses of energy, time and money, saw their lands pass into the hands of powerful capitalists who, profiting from mistakes of their predecessors, achieved success. This has been the history of the majority of arid zones of the valleys incorporated into the irrigated area or the reclamation of the poor and humid marginal areas.

Figure 1.—This map shows the climate in Peru




*This article by two prominent agricultural leaders in Peru was presented at the Eighth Annual Meeting of the SCSA held in Denver, Colorado, November 6, 1953.*

*Luis de Armero Garcia has held many important positions —both as a teacher and an administrator in soils, geology and meteorology. Since 1949 he has devoted his time to managing a farm; also other industrial and business interests.*

*Renato Rossi is director of the "Officina Tecnica de Agricultura"—the first privately owned and financed development of its kind. Mr. Rossi and his associates were responsible for the preparations of the first soils map of Peru. He has also worked on government directed irrigation and reclamation projects.*

*Both men are located in Lima, Peru.*

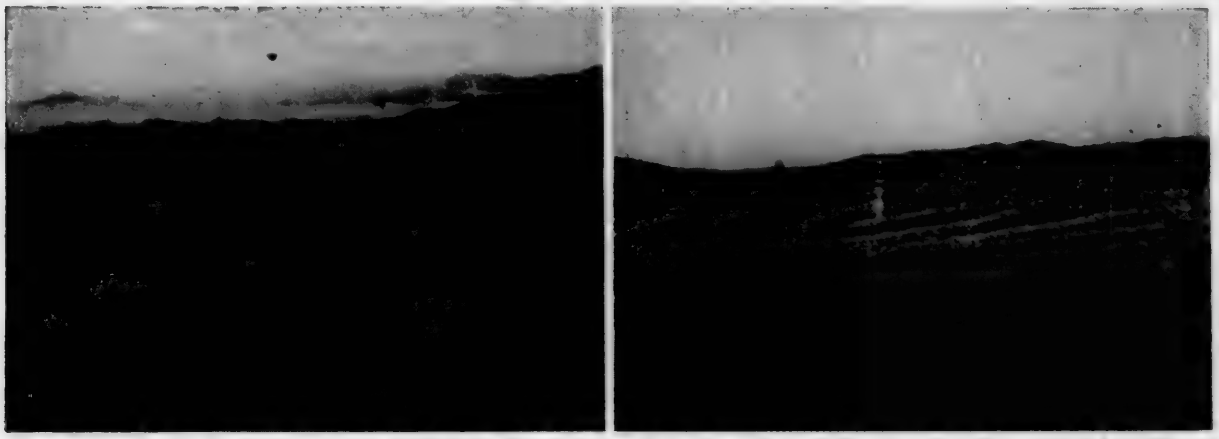


Figure 2. *Left.* A desert area covered with Tillandsia sp. is ready to be reclaimed for agricultural crops. *Right.* These terraces were built for irrigation purposes.

## The Geography and Geology of Peru

Peru, situated on the west coast of South Amercia between latitudes 0°0′48″ and 18°21′03″ south and longitudes 68°39′27″ and 81°21′23″ west, is physiographically divided into three main regions: The coast, the mountains, and the jungle, each with a different geological formation.

The coast, in the major part, is a strip of approximately 120 kilometers (75 miles) wide in the north, narrowing toward the south until it disappears in some cases pushed by the lateral branches of the Andes to appear again at certain distances in vast plains. The coastal formation is principally of marine origin with terraces raised from the ocean floor. The agricultural valleys are of recent geological formation of alluvial origin. The sediments correspond to the Tertiary and Quarternary periods, the Andean branches to the Tertiary.

The mountains are principally of volcanic origin; they are the bulk of the Andes range which extends the length of the country from south to north, emitting in its development a series of branches which leads to the west towards the ocean, and to the east towards the interior of the continent. The high plains of the south of Peru, whose irrigation is being contemplated by the National Plan of Irrigation, are of fluvio-glacial origin. The agricultural areas are found in the depths formed by the slopes and summits of the mountain chains.

The jungle is the wooded, tropical area of the country, the remains of the primitive American continent, the area where serpentine the great tributaries of the Amazon River; also great flatlands and surfaces of gentle relief.

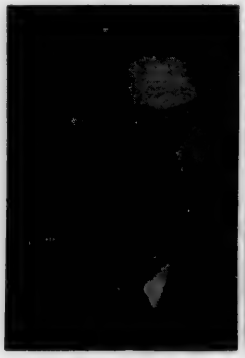
## Climatology and Hydrology

The climate of the sub-tropical coastal desert, according to Koeppen, has an annual rainfall of less than 200 mm. (Figure 1). It is without rain throughout the entire year, except for drizzles and mists during the winter months and slight oscillation of temperature annually and seasonally.

Although due to its geographical position, the Peruvian coast is in the midst of the tropics, its climate is profoundly modified by the cold marine current known as Humboldt or Peruvian which brings cold waters from the depths of the ocean in a south to north direction along the entire shore. This current is one which originates temperatures, peculiar to temperate zones, along the coast, with means of 14-15°C. (57-59°F.) during spring and summer months (November-April) for the central and southern coast; and temperatures a bit higher for the northern coast up to 5° latitude south, which is under the influence of the hot equatorial counter-current "del Nino" (current of the boy, so-called because it starts on Christmas day). The extremes of temperature are moderate, not constituting any danger for vegetation.

The Humboldt current is also responsible for the constant formation of haze, clouds, and fog; the action of the hot air over the cold current condenses the humidity and forms banks of dense fog starting with the month of April and intensifying as the winter progresses. Mists and drizzles fall during the months of June, July and August, in which the relative humidity is very high and reaches intensities of 80 per cent.

However, these characteristics do not affect greatly vegetation in direct form, but do create an atmosphere favorable to the attack of plagues and diseases. They also create a special situation in privileged zones along the coast where the annual rainfall reaches 250 mm. distributed throughout winter months. This gives origin to vegetation of the so-called "lomas" characterized especially by semi-arid plants of the families of the



*Edminster*

*Flory*

*Fuller*

*Williams*

*Benitt*

# Your Fellow and Honora

***Four individuals were elected as Fellow Members of the Soil Conservation Society of America and so honored at the 1954 Annual Meeting held in Jacksonville, Florida. This recognition goes to members professionally engaged in practicing, investigating or teaching soil and water conservation.***

## FELLOWS

**Frank C. Edminster,** New Brunswick, New Jersey. With a national reputation in the fields of land management and wildlife management, Mr. Edminister is a man possessed of keen scientific judgment and integrity. Looked upon by his co-workers as an outstanding figure in the conservation field, he is often called upon for public addresses and his thoughts have done much to further the conservation program in all its aspects. It is in the fields of land and wildlife management, however, where he is outstanding. Currently he is state conservationist for New Jersey, yet finds time to author publications on his favorite subjects. His work on the adaptability of plants for erosion control and soil conservation is considered to be an outstanding practical contribution to the science of soil conservation. He is a charter member of the SCSA; also a member of the National Council.

**Evan L. Flory,** Arlington, Va. Starting from scratch as a research assistant in agronomy on an Indian project, Mr. Flory now is director of soil and moisture conservation in the Bureau of Indian Affairs, Department of the Interior. In bridging that gap of extremes, he has provided outstanding leadership, promoting an understanding and cooperation between Indians and government agencies which has brought exceedingly good results in conservation work. Where an attitude of skepticism first existed, Mr. Flory was able through his persuasiveness and sensible handling of problems to bring conservation programs to 56,000,000 acres in many states on Indian reservations. He holds membership in many societies, has written numerous articles on plant-soil relationships, on which subject he is considered an expert. Currently, he is serving as a member of the National Soil Classification and Policy committees.

**Glenn Loren Fuller,** San Juan, Puerto Rico. Mr. Fuller is a soil scientist and erosion specialist who has pioneered in the mapping of erosion conditions and originated procedures for mapping on which land use capabilities are based. He was formerly a New York State farmer and senior soil scientist for the Soil Conservation Service at Spartanburg, South Carolina where he was in charge of the technical phases of classifying land capability in the nine southeastern states. Mr. Fuller has authored or been co-author of many reports, bulletins and scientific articles; also one of the first men to be associated with Dr. H. H. Bennett when the Soil Erosion Service was first organized. He is a charter member of the SCSA, helped to organize and has headed the Spartanburg chapter and is now on leave from his work in the southeast for special assignments in the Caribbean area.

**Donald A. Williams,** Arlington, Va. Mr. Williams, a charter member of SCSA and member of the National Council, has been administrator of the Soil Conservation Service since November, 1953. He is a native of Clark County, South Dakota, son of a dirt farmer and an outstanding student of the soil. As a graduate engineer, he worked in the field of business and industry until 1935 when he began an illustrious career in soil and water conservation. From then until 1950 he devoted his time and talents to the program of the Soil Conservation Service in the northwest and Pacific states where he was so successful that he went into broader fields of government service. He was particularly outstanding in organization and administrative endeavors and was deeply concerned with water conservation, having a prominent role in the development of "conservation irrigation." He has come up through various Department of Agriculture posts to his present administrative position.

## HONORARY

**William A. Benitt,** Hastings, Minnesota. Mr. Benitt, a Minnesota farmer since 1930, is an outstanding conservationist, district supervisor, and recognized state and national leader. He pioneered the Minnesota Association of Soil Conservation Districts, was its first president and a director until a year ago. Later he helped steer the course of the National Association of Soil Conservation Districts and, because he is an excellent speaker, is frequently called upon to discuss state and national phases of the conservation program. Mr. Benitt is recognized

*Gabrielson* *Heidrich* *Jensen* *Ramser* *Spurr*

# ary Members for 1954

***Honorary Membership in the Soil Conservation Society of America—for outstanding contributions in the field of soil and water conservation—was granted to six individuals.***

for his unselfish gift of time and talents to a great movement to which he has devoted his best interests. He knows, out of his own experience with a 200-acre farm, that conservation pays . . . and pays well!

**Ira A. Gabrielson,** Washington, D. C. Dr. Gabrielson, originally an Iowa school teacher, became in 1940 the first director of the Fish and Wildlife Service, and is looked upon as an outstanding authority on game and fish. That knowledge, gained through close association with wildlife in the field, also brought a knowledge of the fundamental importance of the land in wildlife conservation, a theme which he frequently stresses in public addresses. Through his influence many kinds of media have been prepared to help *"sell"* soil and water conservation and he also has encouraged sound research work. His name appears on the roster of many scientific societies and national organizations, and he holds the Department of the Interior's Audubon award, and two honorary degrees.

**George R. Heidrich,** Charlestown, West Virginia. Bitten by the farming "bug" when 18 years old, Mr. Heidrich, conservation-minded farmer of West Virginia's eastern panhandle country, not far from the nation's capitol, spent many years as an engineer and draftsman before he realized his ambition to handle livestock and till the soil. He is now regional vice president of the 12 northeastern states in the National Association of Soil Conservation Districts, and for three years chairman of the association's legislative committee. He enjoys the healthy respect of his neighbors and others because of the confident, yet unassuming, manner with which he tackles every job. Mr. Heidrich is recognized as a natural leader, a man of many abilities and of keen intellect.

**Ben Franklin Jensen,** Exira, Iowa. A congressman since 1937, Ben Jensen is so completely wrapped up in soil and moisture conservation programs that his colleagues call him *"Mr. Soil Conservationist."* As the tenth child in an immigrant (Denmark) family, he learned early what hard work and planning mean to successful farming. As a congressman he has unceasingly worked for the improvement of the soil, control of erosion, better planning of land resources, better education at the local level and presented clear examples of what conservation practices can accomplish. He, as much as any other legislator, has also alerted city residents to their peril if conservation is not practiced to its physical limits. Soil conservation is his gospel and he its prophet!

**C. E. Ramser,** Washington, D. C. Mr. Ramser, Iowa engineer and "Who's Who in America" since 1946, is known for his knowledge regarding the subject of flowing water as it affects drainage and soil conservation. He has published more than 100 pamphlets, books and government reports on the work he has accomplished. His original research on stream flow in watersheds and studies of the engineering and related factors on farm terracing are followed by the engineering and agricultural professions as gospel. Most of Mr. Ramser's work has been done for the United States Department of Agriculture, but he also has served private industry to develop water resources. He is a charter member of the SCSA and holds membership in many professional and scientific societies.

**Arthur Clinton Spurr,** Fairmont, West Virginia. An outstanding electric utility executive, Henry Laurence Gantt medal winner, holds two degrees from Yale University, veteran of first World War, and a recognized leader in properly publicizing his industry in an understandable manner. He is a disciple of "Enlightened Self Interest," believes the farmer must make money first, has pioneered the conservation program as an every-day procedure with his associates. Mr. Spurr is a past president of American Forestry Association, a leader in many other conservation groups, member of West Virginia University's Board of Governors and director for numerous industrial enterprises. He served on the advisory committee for the Mid-Century Conference on Resources for the Future and is a consistent direct and indirect contributor to all phases of conservation work.

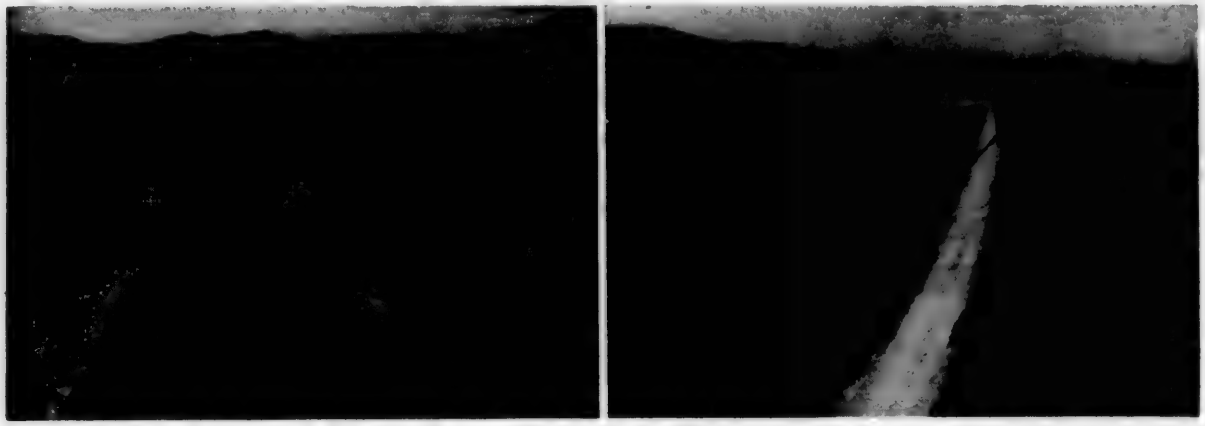


Figure 3. *Left.* An irrigation ditch lined with cement blocks. *Right.* The main canal of an irrigation project.

amaryllidaceous and annual gramineous, castaceous and trees, among which are found the palo verde and those of the genera Prosopis, Pluchra and Capparis.

Winds are moderate, those coming from the south and southeast predominating. During the winter they are cold and humid, while those of the summer are warm wind movement in the same direction has caused formation of sand dunes along certain coastal sections.

Precisely, the coastal climate embraces the following variants of the Leoeppen classification:

1. A climate of drizzles or that of the so-called "lomas"
2. A climate of hot deserts
3. A climate of temperate deserts

This last variant predominates in most of the coastal areas, which when taken in connection with the natural barrier constituted by the chain of the Andes, impedes the passage of humid winds which blow from the Atlantic. A shortage of rainfall causes the majority of rivers emptying into the Pacific to be poor in water. Few have a permanent course, the majority having periodic courses and a certain number having a sporadic course. These rivers are of a little-developed hydrographic system, running in lands of steep slope, and cause a strong erosive action along their entire course. Due to the strong marine current which runs to the north, and to the depth of the ocean, the deltas of river sedimentation are small, almost nonexistent.

Thanks to the fact that during the summer there are rains of moderate intensity in the high parts of the Andes, rivers increase their flow in this period, carrying great quantities of eroded material in their course which is the basis for improvement of the desert plains considered in the plan of irrigation. This gives meaning to the recommendation at the outset to irrigate copiously and repeatedly in the period of water abundance. If followed, this plan leaches the salts peculiar to all desert lands, where physical and chemical disintegration has been slight, and desposits suspended silt and clay, which is highly useful in the coastal sand. Thus the impoverishment of the land in the valley's high regions serves to enrich the lowlands.

With regard to water supplies, we now have inventories, complete for many years in most cases, of water resources of 38 of the 47 watersheds which send their streams into the Pacific.

## Soil Groups in the Desert Area of Peru

With this general background we can now better understand the reason for the great projects of irrigation in Peru.

The total land area possessed by Peru can be broken down as follows:

| | | | |
|---|---|---|---|
| Area of uncultivated land (including area of guano islands of the coast of Peru) | | 49,017,021 | Hectares |
| Forest land | | 71,919,050 | " |
| Pastures | | 8,000,000 | " |
| Cultivated | Coast (irrigated) | 505,537 | " |
| | Mountain | 1,047,050 | " |
| | Jungle | 80,950 | " |
| Lake Titicaca (Peruvian part) | | 488,982 | " |
| | Total area | 131,058,590 | Hectares |

(Based on figures by the Military Geographic Institute)

Since the total population of the country in 1949 was 7,388,960 persons, the number of inhabitants per cultivated hectare is very high: 5.51. This overtaxing of population per hectare regularly cultivated in the coast, deficiently worked in the mountians and very elementally exploited in the jungle, in general terms, has motivated the necessity of incorporating new areas for agriculture and livestock purposes.

The soils of the Peruvian desert region which are artificially irrigated or incorporated into the intensive and modern agriculture by means of the application of reclamation programs, in which the principles of soil

Figure 4. *Left.* Plastic tubes are used to divert water. *Right.* Siltation is a problem in the proper maintenance of terraces.

and moisture conservation are used as a basis, belong in the main, to the great group of deserts of the suborder of light soils of the arid regions and order of the zonals. Most outstanding characteristics of these soils are their light color, coarse texture, and low content in total colloids. (The mineral colloid is constituted principally by clay of the kaolinite type which has low power of cation exchange.)

The content of organic material is related to the natural vegetation which it sustains. Sometimes it is null and other times very weak, resulting from vegetation typical of the desert (among which are representatives of the cactaceous, gramineous, amaryllidaceous and some shrubs and trees such as Prosopis sp. and Capparis sp.) The climate as a pedogenic factor in this great soil group has played a very discreet part. Drainage varies from good to imperfect in a region of flat or gently rolling topography which forms part of the flat sections of the coast known as pampas, interrupted sometimes by the maritime range of the Andes. The predominant soil-forming process is the calcification. The nature of the geological substratum has had an important part in its formation. In relation to productivity, it varies from medium to high when incorporated into an intensive agriculture through irrigation.

In the north of the country, these soils are used as grazing land or their vegetation is employed in making charcoal. Their geographical distribution is along the coastal plains on the desert strips located between the valleys of the coast and first section of the mountains (Sierra).

In the desert zone, we find the great soil group called Sierozem of the suborder of the light-colored soils of arid regions and order of the zonal soils. The characteristics of this group are very similar to the desert soils, for they are light-colored soils, pale greyish, grading into calcareous material at a depth of 30 cm. or less. The native vegetation is desert plants such as cactus, graminae and desert shrubs.

The climatic characteristics are quite similar to those described. Topography varies from flat to steep. To the flat topography belong those high pampas of the south. Drainage varies from good to imperfect. The predominant genetic process of this great soil group is the calcification. At present these lands are used for grazing. When they are incorporated into agriculture through irrigation, the main use is for the production of alfalfa and small grains in rotation. Geographically they are distributed on a strip parallel to the coast with the desert group until 2,000 meters of altitude are reached.

Other great soil groups are known as the Alluvial and Regosols of the Azonal order. The Alluvial has the following characteristics: Its profile is very little developed, stratified; some times there is found accumulated organic matter. Natural vegetation is highly variable, but generally speaking similar to that found in the

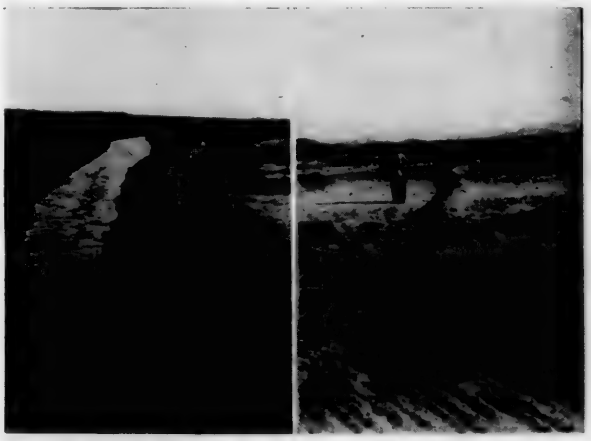


Figure 5. *Left.* Scene of an irrigation ditch in open country. *Right.* Sowing alfalfa on terraced land.

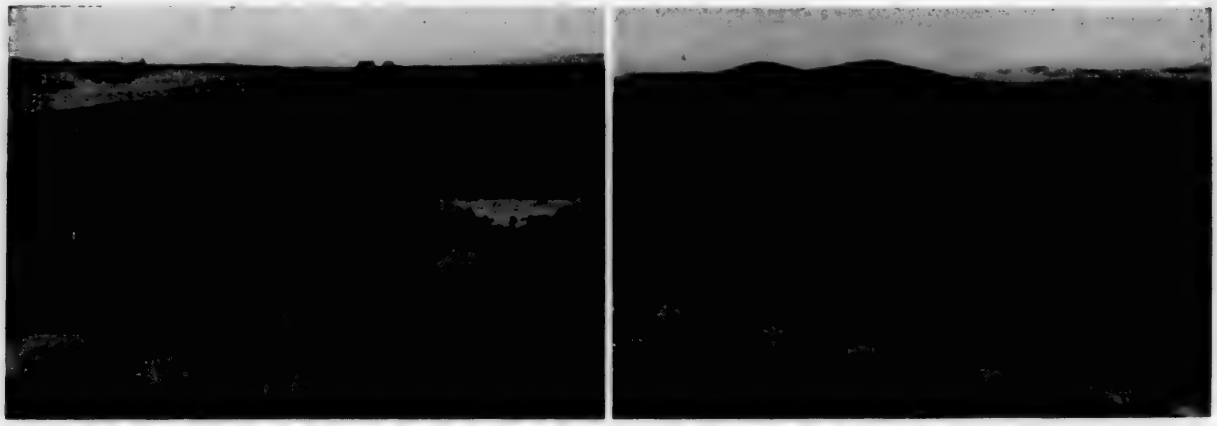


Figure 6. *Left.* Some ditches are stone-lined. *Right.* A fine stand of alfalfa ready to be cut.

desert group. Climate and vegetation as pedogenic factors have little importance in the formation of this group. However, the parent material has had much more influence, for it is comprised of young soils with physical and chemical properties closely related to its nature. The topographic characteristics are variable, but in general the average slope varies from one to ten per cent. Natural drainage is from good to poor. On the alluvial soils are found all the crops which can grow under existing climatic conditions. Yields vary from very low to very high.

This great soil group is located in the valleys of the coast and in the areas located between valleys under the influence of the flood flows of the summer.

In the last place we find the Regosols, which in the Peruvian coast are sands of Eolic origin.

In resume, the predominant soils of the Peruvian coast are characterized by their coarse texture; low colloidal content, especially the organic one; poor structure; and are soils where the climatic canditions are such that the eramacausis or destruction of organic matter takes place rapidly.

**Table No. 1—Irrigated Area in the Peruvian Coast During the Last 25 Years**

| Name of Project | Locality | Irrigated area (hectares) | Area susceptible to be irrigated |
|---|---|---|---|
| San Felipe | Lima | 4,500 | 5,000 |
| Vilcahuaura y Miramar | " | 2,500 | 2,500 |
| La Esperanza y Huando | " | 6,000 | unknown |
| Chilca | " | 1,885 | " |
| Asia | " | 699 | " |
| Imperial | " | 8,156 | 23,000 |
| Cabeza de Toro | Ica | 4,000 | unknown |
| Pampa de Los Castillos | " | 20,000 | " |
| La Joya | Arequipa | 3,352 | 12,000 |
| Sta. Rita de Siguas | " | 2,610 | unknown |
| Pampa Colorada | " | 500 | " |
| Mollendo, Ensenada y Mejia | " | 2,000 | " |
| Ite Norte | Tacna | 1,972 | 15,000 |
| Uchusuma, La Yarada | " | 500 | 30,000 |
| Total | | 58,674 | |

## National Plan of Irrigation

During the last 25 years the Government, private irrigation enterprises, and individual farmers have been developing small areas of arable land along stream banks where sufficient water was available all the year round. Also, new desert land has been incorporated into intensive agriculture through irrigation. In both cases irrigation is being practiced by gravity and pumping water. The size and distribution of the desert area incorporated during that period of time is shown in Table 1.

On the basis of the experience gained in the past and on the basis of the soil inventory already outlined, it is easy to understand the past and present interest of our Government to irrigate our huge desert area, building reservoirs, diversion dams, canals and tunnels in the heart of the high Andes to divert water to those sections of the coastal pampas having good soils and convenient topographic features. The water that runs in the canals and tunnels causes the desert area to come to life. It is, indeed a miracle in this age. The results of these developments by the Government brought forth the National Plan of Irrigation.

Under this scheme Peru plans to incorporate for its agriculture 534,100 hectares of desert land (approximately 1,320,000 acres), and also improve the water supply for irrigation in 356,200 hectares (approximately 880,000 acres), as well as produce hydroelectric energy at an approximate cost of 4,487,000,000 Peruvian soles (U. S. $264,000,000). Some of these projects demand storage supplies and importation of water from other

Figure 7. *Left.* A mechanical hay baler at work. Modern farm equipment occupies an important place in Peru's irrigation and reclamation program. *Right.* Windbreaks, using casuarinas, are an important need in some sections of Peru.

watersheds, especially from those located on the eastern slope of the Andes or the so-called Atlantic basin with excess of water supplies available. As of now the economic magnitude of these projects is feasible only as undertakings by the Government or large companies.

Parallel to the national plan, private enterprises (Peruvian as well as foreign) are planning to irrigate new desert land and reclaim marginal areas to incorporate them into the agriculturally productive area.

Besides the irrigation projects, the Government is using the due water of the "lomas" for the establishment of forests, such as Lachay, located north of Lima where there is a woods of eucalyptus, casuarinas and tamarix. Hedges of agave have been growing nicely for 20 years.

Each irrigation project before going into the process of land development, follows these phases:

Study of the project
Financing
Construction

The phase of study can be preliminary and final and is comprised of the following:

Topographic studies
Aerial survey
Soil survey
Hydrology
Geological survey
Meteorological studies
Hydraulic and structures
Communication system
Hydroelectric energy
Land settlement
Land development

In the financial stage the approximate cost of the project is studied, along with the program of construction, and the bulk of material to be used. During the last stage, on the basis of results of all of the foregoing studies, actual construction is accomplished. As soon as the project is finished, the process of developing the land will start.

## Land Development Program

As soon as the hydraulic work is finished and the water is in the higher part of each farm unit into which the area of the project has been divided, the process of land development starts.

In order to be more factual in the description of the procedure of preparing for irrigation in Peru, we are going to use the example of the San Felipe irrigation project, located 150 kilometers (93 miles) north of Lima, where the land development process started in 1949, taking the following steps:

Having as basic background the series of studies mentioned elsewhere for the majority of the 101 farm units (100 of 40 hectares each and one of 500 hectares) into which the whole area of the project was divided, a farm plan was developed. This plan has two main parts:

The first consists of a land-use map on which is shown the entire system of subdivision of the unit into fields of suitable dimensions; the water distribution system; the interior roads; the location of the buildings and installations and the system of soil and water conservation practices.

The second part covers a description of the plan of operations, stating what is to be done and where the specific practices are to be established in each field or each farm unit.

As soon as the farm plan was completed, construction started. This phase was characterized in San Felipe by great speed and investment of considerable sums of money. Its particularities can be summarized as follows:

1. Elimination of the natural desert vegetation, stones or any other obstacle to the crop to be established.

2. Land levelling and construction of the systems of irrigation and drainage ditches, interior roads, terraces, etc., in order to put each field in condition to receive irrigation waters.

3. Irrigation to complete leveling, leach the salts, facilitate siltation and obtain a bed sufficiently moist for the alfalfa seed to be sown.

4. On the basis of the soils and climatic conditions, the existing plagues and diseases, as well as the possibilities of economic returns, alalfa was chosen as the first crop to be grown in San Felipe. In that manner, in 1949, the first plantation was established using inoculated seed. Now more than 3,000 hectares (7,410 acres) are covered by alfalfa.

5. The harvest as well as manipulation of the hay is done mechanically. Yields vary from 10 to 12 tons of hay per hectare per year, distributed in seven cuts. Little by little the introduction of Holstein-Fresian dairy cows is taking place and in that manner the system of harvesting is being replaced by direct grazing.

### Conclusions

As can be understood from the foregoing, Nature was not too generous with Peru. She did not give us first-class lands, she handicapped the distribution of water putting the high Andes as the backbone of the country, carrying excess of water to the eastern slope and creating conditions of extreme dryness along the western slope. However, let us thank her, because she drives us to resolve important agricultural and civil engineering problems as well as social and economical ones in order to obtain high benefits as a final result. Considering this, the famous phrase of the Italian scientist, Antonio Raimondi, father of Peruvian natural science, is very appropriate:

*"Peru Is a Beggar Sitting on a Bench of Gold."*

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## Use of Aircraft in Soil Mapping

(*Continued from page 256*)

formity of the parent materials. An example would be a uniform sand plain or a residual soil area, where the only limiting factor in mapping the soils is the speed at which the surveyor can cover the ground. Such areas often contain simple slopes and have a limited number of soil types. Here, the use of an airplane following preliminary ground investigations might conceivably increase the production rate of maps by at least three or four times. This obviously would result in a considerable saving in time and expense. In more complex areas, the necessary additional ground checking tends to reduce, and in some cases may even eliminate, this saving.

Like the stereoscopic method, the air method may be very desirable in making reconnaissance surveys of inaccessible, undeveloped areas proposed for agricultural development.

Although the depth of surface soil can be accurately determined on the ground using a soil auger, the mapper often experiences difficulty in sketching the boundary of a particular area after it has been identified. On the other hand, an experienced air mapper from his vantage point directly above the soil area usually can detect significant color-tone differences which will enable him to sketch the boundary between two different soils with more accuracy than on the ground.

### Summary

The air-mapping technique has been presented as a relatively fresh approach to soil mapping. Preliminary studies indicate that this method offers many advantages and further studies are proposed in order to fully determine its usefulness.

In view of the magnitude of the survey job yet to be done in the U. S. and the limited number of competent, fully trained soil scientists available, it would seem that the use of any time-saving implement or method would be highly advantageous.

Although we have no thought that air mapping will competely supplant ground mapping, we are convinced that intelligently applied aerial study can reduce the amount of ground observation necessary and with results equal to or more accurate than those obtained by ground survey alone. To this extent a substantial saving of time will result.

# Soil Erosion Survey of Latin America

**The Conservation Foundation and the Food and Agriculture Organization of the United Nations**

***This Survey, presented in three parts,* is the result of a cooperative venture between The Conservation Foundation and the Food and Agriculture Organization of the United Nations. Under the technical direction of FAO, field reconnaissance was used to supplement and verify conclusions drawn from geographical correlation techniques. The three maps represent the first real assessment of the degree to which erosion has ravaged Latin American soils. Of necessity, and by design, such a survey must be highly generalized. It is hoped that its findings will stimulate individual nations to study in greater detail the facts and implications of soil erosion within their borders.***

## Part III
## AGENTS OF SOIL EROSION

Erosion is the detachment and movement of soil or rock material. It goes on whenever the earth's surface is subject to the action of rain, flowing water, ice, wind, or gravity. The rate of erosion depends on such factors as detachability of the material, size and density of the particles, and force exerted by the transporting agent. It also depends on the protection given by vegetation or other material. The types of erosion may be classified according to the erosive agent: water, wind, ice, or gravity. Water erosion, the chief type, is further divided into sheet, rill, gully, and stream-bank erosion.

### Water Erosion

Water erosion is likely to occur wherever rain strikes the land and causes runoff. The instant they fall onto the ground, raindrops become a major factor in the erosion process.

Whenever rain falls on bare soil, the first few drops will loosen the soil particles and wet them. Unless the soil is pure sand, the water is made muddy with suspended soil. This water enters the pore spaces in the soil and the suspended material is filtered out and tends to fill them. If the rain comes faster than it can enter the pores at the soil surface, water accumulates. First it forms a layer of saturated soil on the surface. As more water falls, it collects in the low places. If the land is sloping it runs into a channel and on downhill. As soon as the film of saturated soil is formed at the surface, the next raindrops will set in motion a violent local stage of the erosion process.

Each new drop, as it hits the film of muddy water already there, splashes with explosive force. First a ring of water, shaped like a deep saucer, is formed around the spot where the impact occurred. The diameter of this ring is about four or five times as great as that of the drop that caused it. Within a split second the outside edge of this ring separates into tiny droplets, and these continue their upward splash. Often the splash reaches a height of 2 or 3 feet above the ground. Mud splashed in this way may be seen at the base of any wall, especially on a freshly painted one. Soil particles, sand, and even fine gravel are splashed into the air by the force of the rain.

If the splash occurs on a perfectly level surface, the gain of soil particles at any one point balances the loss. There is no net loss and hence no erosion. If the process occurs on a slope, the splashed soil travels farther on the downhill side, and the net effect is a movement of soil down the slope. If running water is moving down the slope at the same time, some of the splashed material is carried or rolled along with it. Such removal of soil in a thin sheet is called *sheet erosion.*

Since few surfaces are perfectly smooth, water does not flow far in a uniform sheet but collects in rivulets. As long as the rain continues, each rivulet is kept

*The preparation of the* Soil Erosion Survey *was under the overall direction of Dr. Mark Baldwin, consultant on the staff of the Food and Agriculture Organization of the United Nations and formerly of the Division of Soil Survey, U. S. Department of Agriculture. Dr. Baldwin conducted the field work in Mexico, Central America, and the Caribbean. He is a pioneer in the classification of degrees of soil erosion from aerial photographs and this method was used in many areas where field work was not practicable. Under Dr. Baldwin's general direction, the field work in South America was carried on by Charles S. Simmons of the Foreign Agricultural Service, U. S. Department of Agriculture, who covered western South America, and Dr. W. F. van Beers, Soil Scientist, FAO, who covered the eastern part of the continent. The manuscript, submitted by the field staff and revised by Dr. Baldwin, was consolidated and edited by Peter M. Stern of The Conservation Foundation. Part III was contributed by Dr. J. G. Steele, Soil Conservation Service, U. S. Department of Agriculture in collaboration with Dr. Baldwin. The maps were drafted from field compilations by F. J. Marschner of the staff of FAO and formerly of the Bureau of Agricultural Economics, U. S. Department of Agriculture.*

Parts I and II, which appeared in the July and September, 1954 issues of the Journal, dealt with soil erosion in Mexico, Central America, the West Indies and South America.

supplied with detached, suspended particles by the action of the falling rain. In addition, soil particles in the running water scour the sides and bottom of the tiny channel and enlarge it. Then the process of *rill erosion* is under way. A rill is a channel no deeper than plow depth that can be smoothed out by the next cultivation. In a cultivated field, rill erosion has about the same effect on the land as sheet erosion.

If the channel becomes so large that it cannot be smoothed out completely by cultivation, it is a gully and the process is called *gully erosion.* A gully is distinguished from a rill because of its greater size. Gullies ordinarily are formed in natural waterways. To prevent or control them, it is necessary to dispose of the water so that it either does not reach erosive velocity or does not flow over unprotected soil.

Since rain splash is a major source of stirred-up soil for sheet and rill erosion, we must shield the surface soil if we want to control erosion. That is why sod, stubble, leaf litter, and mulches are indispensable soil-conservation tools. *Soil conservation begins with the taming of raindrops.*

### Gully Erosion

The cross section of a gully is often shaped like a shallow V, with convex slopes that are steeper at the bottom than at the top. V-shaped gullies are formed where the subsoil is tough and somewhat resistant to erosion. Somewhat similar gullies, and sometimes larger channels or washes, are formed where an intermittent or permanent stream flows through a valley deposit of deep alluvial material. Such channels are common in semiarid and arid regions.

The formation of U-shaped gullies has been studied in detail. Their development often takes place in four distinct stages. First a small channel, or rill, is formed in the topsoil and the clay subsoil. This is a V-shaped gully. The second stage begins when the gully penetrates into the underlying more easily detached material. This layer can be either weathered rock or material that accumulated on lower slopes as a result of gravitational creep. It may also consist of unconsolidated sedimentary beds or recent alluvial deposits. When a gully enters the second stage, the detachable material is carried away rapidly and an overhanging head of resistant subsoil is quickly formed. Water flows over this head, the resulting waterfall cuts away at the base, the upper bank collapses, and the gully grows rapidly headward. During this stage the gully has steep sides and there is no chance for vegetation to become established either on the sides or on the bottom. The third stage begins when the channel has eroded to a local base level and water barely flows in the bottom of the gully. At that point there is no longer any appreciable amount of downcutting. Then the sides gradually acquire a gentler slope as soil material is eroded from them and accumulates at the base, and plants can begin to grow in the gully. This stage merges into the fourth stage in which the gully is stabilized by vegetation, the slope becomes somewhat more rounded, and organic matter accumulates gradually in the newly forming topsoil. In arid regions, however, the cycle tends to become arrested in the third stage, and the landscape remains characteristically angular.

### Wind Erosion

In both wind erosion and water erosion a fluid in motion acts as the transporting agent. Wind erosion, like water erosion, occurs when the transporting agent has enough velocity to permit it to carry particles of soil and when a supply of detached or easily detachable particles is available. There are important differences, however, between water erosion and wind erosion. The velocity and hence the carrying power of wind is independent of slope, or nearly so. Moisture in the soil acts as a binding agent as long as it lasts. A moist soil does not blow until the uppermost exposed film of earth becomes dry. Dry, loose sand of coarse or medium texture is especially subject to wind erosion. A dry, granulated, fine-textured soil will blow if the granules are fine enough, even though it is not dispersed into fine dust that can be carried long distances. Finely divided organic matter, the most valuable part of any soil, is the part most likely to be carried far away by wind erosion.

### Geological Erosion and Accelerated Erosion

In preparing a map of the incidence of soil erosion, particularly on a generalized basis, it has been found most difficult to distinguish between normal or geological erosion and man-made or accelerated erosion, especially in dry regions. In fact, not everywhere has such a distinction been attempted. In arid and semiarid northern Mexico, for example, it is certain that much of the soil erosion now in progress is geological erosion that has been accelerated by overgrazing.

Erosion as a natural geological process has long been recognized and described by geologists. In fact, most of the details of the earth's present relief patterns were formed by the erosive forces of water, glaciers and wind, all under the broad influence of gravity. These are continuing processes, regardless of the acts of man. But man in his use of land and its products has changed the speed, though not often the direction, of these forces and this man-made speed-up has been variously called accelerated erosion, man-induced erosion, or simply soil erosion. The term "soil erosion" may therefore refer to

the removal of soil after human disturbance as contrasted to "geological erosion," which is the wearing away of the land and the formation of erosional, residual, and depositional land forms by the normal and more orderly processes.

The distinction between geological and accelerated erosion is not particularly difficult to discern in the well-clothed lands of the humid, forested regions of the earth. Here the soil layers are held in place quite firmly and, although natural processes were of course at work before the arrival of man, there certainly was little bare earth from which clay, silt, and sand could be easily or rapidly removed. This picture changed when the land was cleared of forest and brought under cultivation, particularly under clean-cultivated crops like corn and cotton. Soil erosion, definitely accelerated by the acts of man, proceeded rapidly and became so conspicuous that there was and is little difficulty in distinguishing between normal or geological erosion under natural conditions and accelerated soil erosion induced by land use. A similar situation prevails in the humid and subhumid grasslands. Here the native grasses and grass roots held the soil against rapid erosion and the high organic-matter content of the soil (chiefly derived from the grass roots), by its influence on soil structure, not only helped retard erosion before the land was cultivated but checked the speed of soil loss after the land had been plowed.

Over the arid lands of Latin America where the rainfall is 20 inches or less and vegetation protected the soil only partially, conditions favored a rapid and definite shifting of the surface materials by natural processes. It is in these arid and semiarid regions that the distinction between geological and man-made erosion is difficult to draw. There was a very delicate balance in nature between the components of the soil-water-vegetation complex. Any slight disturbance of the ground cover, chiefly by grazing animals, was sufficient to disturb this hair-trigger balance and to produce a marked degree of accelerated erosion. An additional factor in this rapid erosion is the torrential character of much of the rain in the arid and semiarid regions. So completely have the lands of the arid and semiarid regions of Mexico and other parts of Latin America been grazed that some degree of accelerated soil erosion by water or wind has occurred everywhere except in spots where there had been no loose soil material in the first place—only bare, hard rock. To assess the extent of soil damage inflicted by this man-made erosion is a difficult problem. It is certain that the loss of an inch or two of surface soil is in general more serious than in humid regions for even such a thin layer generally forms a high percentage of the total soil mantle and contains most of the organic matter. There has been perhaps a tendency to underestimate the importance of accelerated soil erosion in the arid regions because of the very spectacular nature of rapid geological erosion, and the real difficulty of distinguishing between the two.

Other soil movements particularly common in the hilly and mountainous, humid and superhumid regions of tropical America are those which result in landslides, landslips, soil slumps, "catsteps," and mud flows. These mass movements have various causes for which man is not responsible. These may be quakes, volcanic eruptions, torrential rains, and avalanches, and the slower, less spectacular processes of faulting, glaciation, and physiographic rejuvenation due to inner earth movements. Man often accelerates these mass movements of soils and soil materials by clearing and cultivating the land on steep, unstable slopes; by denuding the surface with fire, overgrazing, and unwise logging; by irrigating slope lands, and by mining and engineering works, particularly road building in mountainous terrain. While the natural and the human processes and factors involved in this type of soil movement can be defined and distinguished, it is often difficult to evaluate the influence of each of these factors. For, after all, accelerated soil erosion is simply a speeding up of natural processes.

## Soil Erosion, Climate and Vegetation

The relationship of climate and vegetation to soil erosion is obvious, although the details are still being investigated. Wide experience and observation indicate clearly that the degree of soil erosion is not a simple function of total rainfall; in fact, it is generally true that, other factors being approximately similar, soil erosion is at a minimum in regions with very high and uniformly distributed rainfall. Where total annual precipitation is 100 inches or more and well distributed (such regions are mostly in the tropics), there is less destructive, accelerated soil erosion than in less humid regions. The reasons for this may be listed as follows: weathering and soil formation under such high rainfall produce a deep, permeable soil which resists erosion; the very dense natural vegetation on such land protects the soil; there is reduced incentive for permanent human occupancy of such lands, for they are generally infertile and hard to clear of the native growth. There is little destructive burning on such lands. The cultivators may use fire in clearing land, but such fire seldom gets out of control to burn over thousands of acres, as it does in less humid climates.

Wild fire is especially destructive in regions with well-defined dry seasons. Dense brush cover is particularly vulnerable to fire, and when the dry season is followed by heavy rains, as it often is, soil destruction on sloping lands is very severe. Not only is there severe

erosion on the hill lands but accompanying destructive floods cause much property damage, loss of life, and ruin of fertile farm lands in valleys and plains below. The following table illustrates in simplified form the relationships among climate, vegetation, and soil erosion in Latin America.

| Climate | Vegetation | Soil Erosion |
|---|---|---|
| Superhumid | Rain forest | Slight or moderate land slips and some deep gullies in unstable terrain. |
| Humid | Forest | Moderate and severe on sloping lands where cleared and cultivated to row crops. |
| Subhumid moist | Tall grass | Generally, none to moderate on smoother lands; moderate to severe on sloping lands in warmer climates. |
| Semiarid | Short grass | None to moderate on smooth lands in cooler regions; moderate and severe over large areas, particularly in Mexico. |
| Arid (intermingled with semiarid) | Desert plants—chiefly desert shrubs and cactus | Moderate and severe—much geological erosion, accelerated by overgrazing. |

The native vegetation has been disturbed by man over 75 per cent or more of the earth's land area, exclusive of the polar and subpolar regions, and this disturbance, except on level lands, has resulted in some degree of soil erosion.

Nature attempts to reclaim eroded lands by establishing a vegetative cover wherever such lands are abandoned or neglected by man. The speed and success of such natural rehabilitation depends on climate, slope, the kind and degree of erosion, the nature of the soil material, the availability of seed of plants adapted to the environment, and the degree of cooperation by man. In fact, man and nature are often in conflict in this process of revegetation. For example, the natural establishment of unpalatable plants on overgrazed and eroded lands in the semiarid and arid regions checks soil erosion but is considered undesirable by ranchers who regard these plants as pests. Elsewhere lands eroded and abandoned for crop production may grow up in young trees and brush so thick that hunting becomes difficult. So, the hunters burn over the land, and nature must start in anew on her erosion control program. Or stock raisers may burn off coarse, dry vegetation in winter in order to take advantage of a very short season of scanty but succulent pasturage. And, in a sense, the shifting cultivators of the tropics do the same thing when they destroy a second growth to raise a crop or two. However, over thousands of square miles in the tropics, nature has won out over man with cogon grass (*Imperata cylindrica*), a plant that is capable of holding the land against any efforts on the part of small cultivators to exterminate it, wherever climate and soil are favorable to its growth.

Many examples could be cited of the influence of soil erosion on vegetation and the effect of climate on both. The effects are complex and are made more complex by the intervention of man in the natural processes of soil restoration.

## Soil Erosion and Land Relief

Water erosion occurs only when the slope gradient is sufficient to give runoff water an erosive velocity; that is, a velocity that enables it to carry or move soil materials. Slope gradients is one of the most obvious and measurable features that control the speed and severity of soil erosion. But its particular role in the complex of factors that govern water erosion cannot be expressed by a mathematical measurement of the degree or per cent of slope. On certain black soils of the warm climates, for example, where rains come in the form of heavy downpours, erosion on 1 per cent slopes may be so severe as to require definite control measures. On the other hand, clear water has been observed running off slopes with a gradient of as much as 25 per cent, where the crop was young sugar cane and the soil unusually resistant to erosion. But, to make a general statement, on slopes of more than 2 per cent the soils of the humid regions are vulnerable to erosion where they are cultivated and where the rain falls in vigorous showers. In semiarid and arid regions of sparse vegetative cover, overgrazing may render any slope of 1 per cent or more vulnerable to damaging soil erosion by downpours occurring at irregular intervals.

Gradient is not the only component of slope to affect soil erosion and govern methods of erosion control. Other features are shape (i.e. whether concave or convex), length, and pattern of the slope complex. In some areas the land surface consists of such an intricate jumble of slopes of varying direction, length, and gradient that terracing is not feasible, except where labor is abundant and cheap and the crops are of high unit value and in great demand. Erosion on such land must be controlled, for the most part, by planting and maintaining an adequate cover of trees, shrubs, or grasses.

Wind erosion is independent of slope and may occur on flat land; in fact, wind erosion is most severe on broad, open plains such as the subhumid and semiarid western Argentine Pampa. But much wind erosion does occur on gently sloping or gently undulating lands where it often works in combination with water erosion.

### Soil Characteristics and Soil Erosion

The principal soil factors that affect erosion directly are texture, structure, and permeability of the soil at the exposed surface, and permeability of the subsurface and subsoil layers. Structure, in all except very sandy soils, depends on the type of clay minerals, the amount and kind of organic matter, the amount of microbial activity, the dependability of the moisture supply, and the degree of compaction resulting from tillage, trampling, beating of raindrops, or infiltration of fine particles.

Sands are relatively resistant to sheet erosion. Water enters them readily. Runoff must occur in considerable volume and must have fairly great velocity to be able to move the grains. Sands and very loose sandy soils are highly erodible, however, whenever water flows across them rapidly. The grains are easily detached and are eroded as rapidly as the water can carry them. However, most sandy soils are not pure sand but contain a substantial percentage of fine material which consists in part of mineral grains of silt and clay dimensions, and in part of organic matter. This latter fine material, the only ingredient of a sandy soil that holds significant amounts of moisture and plant nutrients, is especially vulnerable to erosion. It is easily sorted out from the sand by rain splash or by flotation, and is carried away if runoff occurs. Runoff of muddy water from a sandy field is serious, even if to all appearances the topsoil is left intact.

Plastic clays are relatively resistant to erosion if they are tough and difficult to detach. Nonplastic, highly aggregated clays are extremely erosion resistant. They form stable granules and do not swell or become sealed upon wetting. They are the lateritic clays of some parts of Cuba, Jamaica, Puerto Rico, Central America, tropical Mexico and tropical South America. By way of contrast, easily dispersed silts or clays form some of the most erodible soils found anywhere. Some of the medium- and fine-textured soils of the arid regions are difficult to irrigate and extremely erodible. In general, soils that have a high content of silt, that is of the floury particles intermediate in size between sand and clay, are highly erodible. Although a cut bank in this soil material stands up almost vertically, the surface soil erodes rapidly wherever the natural structure is disturbed by cultivation or grazing.

The structure of a cultivated topsoil depends greatly on the amount and kind of *organic matter* in it. Fresh organic matter on the surface protects the soil from both water and wind erosion. Mixed with the topsoil, organic matter furnishes temporary channels for water as it shrinks and decays, and helps the penetration of water and the stabilization of the soil. It supplies energy for the soil organisms which in turn promote the formation of stable granules. Some of the fungi are particularly effective in promoting granulation.

Succulent organic matter is oxidized rapidly in the soil and contributes relatively little to the long-term supply. Mature, woody materials such as stubble, stalks, straw, or sawdust are decomposed more slowly and are more likely to promote desirable tilth. Also, a good supply of nitrogen is needed for the formation of the relatively stable lignin-protein complex that is commonly called humus.

Although soil factors by themselves affect the rate of water erosion significantly under some conditions, they must always be considered in relation to slope and cover. Almost any soil in a humid region can be maintained on any slope without excessive erosion if the protective cover is as good as it was under virgin conditions. Conversely, any soil will be eroded if it occurs on a slope and is clean-cultivated for a long period without soil- and water-conservation practices. To control erosion, therefore, cultivation should be practiced only on slopes that can be stabilized under a reasonable system of land management. Then the soil factors become very significant in governing the choice of economic plants to be grown and the most desirable methods of cultivation and treatment to be adopted.

### Influence of Erosion on Soil-forming Processes

Geological erosion, at the slow rate at which it occurs under a good cover of vegetation, counteracts but does not prevent soil formation. On many slopes of 10 per cent or more the soils are shallow and consist in part of fragments of the rocks from which they are formed. Often the entire unconsolidated layer, including true soil and weathered rock, is only 2 or 3 feet thick. As long as erosion is not accelerated by man, the leached and weathered products of soil formation are gradually removed and added to some alluvial deposit or carried to the sea, and the hillside soil is in a sense rejuvenated by the exposure of more freshly weathered rock fragments. If the underlying rock is one containing a variety of minerals, as is the case in most igneous rocks and many kinds of limestone, a soil fairly rich in mineral nutrients is maintained.

Acid sedimentary sandstones and shales, however, laid down during former geological ages, are composed of materials that have been leached almost free of lime and other soil-improving minerals. Under such conditions geological erosion, where rapid, tends to produce shallow, stony soils that are only fairly fertile at best. Accelerated erosion on such land quickly upsets the precarious balance that existed in nature. Loss of the topsoil, or a major part of it, is serious. Loss of the entire soil

down to bedrock usually makes the land worthless for crop production and of little value for grazing or forestry.

The effect of accelerated erosion on soil productivity depends on the kind and depth of soil material that remains. In many types of soil the loss of topsoil to a depth at which the plowed layer is diluted with underlying subsurface or subsoil material causes noticeable changes, often accompanied by reduction in crop yields. Further erosion requires special soil-building practices if yields are to be maintained or restored. The process of full restoration may be a long one. The subsoil is usually heavier in texture than the topsoil as a result of normal soil development. Areas where the soil is shallow or only moderately deep over rock, gravel, tough claypan, hardpan, or hardened accumulated lime are of little value once they have been seriously eroded. There are types of soil, however, in which erosion exposes workable materials that can be reclaimed without undue cost. This is especially true where the parent soil material is rich in the mineral elements of fertility such as calcium, potassium, and phosphorus. These are the soils that have developed from, or are underlain by, soft limestone or marl, calcareous shale, calcareous loess, and basic volcanic ash. Certain lateritic soils, which are permeable and of favorable structure to great depth, can also be reclaimed by adequate applications of lime and fertilizer, the growth of legumes and grasses, and good soil management.

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# Book Reviews

**THE USE OF WOOD CHIPS IN AGRICULTURE.** *Report of Conference at Syracuse, New York, Northeastern Wood Utilization Council, Inc., New Haven 6, Connecticut, 96 pp. October 3, 1953. $2.00.*

Tih is a group of short papers describing how wood chips and sawdust may be utilized to advantage in different way in agriculture. Attempts have been made to determine the real value of chips in relation to sawdust and straw as bedding for cows. Chips of about ⅛-inch thickness appear to be satisfactory from the standpoint of animal choice.

In Connecticut, applications of chips to soil nearly always reduced crop yields the first year and frequently later, unless supplemental nitrogen was added. There appeared to be no specific toxicity of the chips or of sawdust, aside from the induced nitrogen deficiency.

Experiments conducted in Rhode Island showed that after two years, only meager accumulations of organic matter had taken place.

The bulletin, as a whole, presents useful information regarding the production and use of chips. It cannot be said, however, that the economics or the long-time usefulness of these materials has been well worked out.

—M. S. ANDERSON, *Beltsville, Maryland*

**BIG DAM FOOLISHNESS,** *The Problem of Modern Flood Control and Water Storage.* By ELMER T. PETERSON, *with introduction by* PAUL B. SEARS. *224 pages, illustrated. Devin-Adair Co., 23 East 26th St., New York 10, N. Y. $3.50.*

This is probably the most outspoken book yet published on the subject of water conservation. It should either make you mad or disgusted.

If you favor hurrying the water to the sea as fast as possible just to get rid of it, you'll probably get pretty riled up at the author, because he violently opposes that idea. If you agree with the author that we should hold the water on the land as long as possible, you may throw up your hands in disgust at the fumbling, bungling and waste described in the numerous case histories cited by Elmer T. Peterson.

It seems he has talked with or read after just about every important personality associated with conservation and has a thorough background on what happens to the water and the land when it rains. He has personally visited many of the big dams, little dams and watersheds around the country that he writes about. He has the facts to back up his statements, even though many of them are pretty strong.

A particular object of Peterson's blasts is the Pick-Sloan plan to spend $57 billion (or more) for big dams, a project that is supported by many politicians who hope to maneuver some of the spending into their own districts. Peterson thinks that if it is completed "we will have a stupendous series of bowls receiving land-soup—the rich life blood washed out of the soil."

However, he fires away with both barrels at the U. S. Army Engineers, the Missouri Valley Authority, the Columbia River Authority and the Tennessee Valley Authority (TVA) because "they set up a quasi-totalitarian government-within-a-government." The Department of Interior's Bureau of Reclamation, Peterson says, has a conservation plan that mainly coincides with that of the Pick-Sloan plan, with public power as a chief objective. He notes that the Soil Conservation Service (SCS) is committed to a flood control plan that the Army Engineers repudiate but that SCS is too weak to assert itself.

In presenting his case, Peterson makes a scathing 18-point indictment of the whole "big dam foolishness" and then cites case after case to show how vast sums of public money are being wasted on high-cost projects like the Grand Coulee dam with alleged multiple uses that don't work out.

Peterson's obvious hope is that more people will become aroused like citizens in the Blue Valley section of Kansas and rise up to smack down big dam proposals and some politicians along with them.

Constructively, Peterson presents a powerful case for watershed treatment with stepped-up insoak to save the water where it can be used. He appeals for more research on insoak and ground water storage because he believes this alone will be our salvation. If we accomplish it, Peterson eloquently visualizes increased farm prosperity, high water tables, revived springs, clear streams running deep, better fishing and other recreation, more irrigation, complete flood prevention, health for the people, and a conservation system that will pay for itself and keep the people on the land.

An editorial writer for the *Daily Oklahoman,* leading state newspaper in Oklahoma City, Elmer T. Peterson is famed nationally for his crusade for conservation. His skill as a writer is reflected in many neatly-turned phrases throughout the book, such as: "The wilderness is never defeated"; "Municipalities, being human, are unpredictable"; and "Floods are unnecessary, not acts of God, but results of man's carelessness or neglect." Peterson has written several good books on farming previously, perhaps best known among them being *"Forward to the Land"* and *"Cities Are Abnormal."*

In the introduction, Paul B. Sears (famous for his own *"Deserts on the March"*) says this book might not be necessary if three generations of science teachers had done a better job for the present American public. Evi-

dently he agrees with Peterson that we have foolishly adopted a scheme of big dams that "are foreign to a beneficent wilderness, in which every detail argues for the little waters." In his concluding chapter, Peterson dreams for the future that the sham battle of the bureaus may be ended, that we may learn to hold and use the water that God and nature provide, so that man be happier and healthier dwelling in a land that knows the ravages of neither drouth nor flood. He thinks that time will not come until we get rid of our "big dam foolishness."

—F. J. DEERING

**ELEMENTS OF STATISTICS.** *By* H. C. FRYER, *John Wiley & Sons, Inc., 440 Fourth Avenue, New York. 263 pages. 1954. $4.75.*

By supplying a concise and general background in probability and statistics, Dr. Fryer gives the fundamentals applicable to all fields, without stressing any specialized area. He therefore draws extensively on examples from biology, economics, engineering, medicine, education, psychology, agriculture, and other fields that utilize statistical research.

After a brief history of the subject, the author covers the summarization of sets of data involving one type of measurement, elementary probability, and the binomial and normal frequency distribution. He also eplains sampling from binomial populations, introductory sampling theory for a normal population involving only one variable, and linear regression and correlation.

**ECONOMIC RATING OF SOILS FOR TAX ASSESSMENT.** *By* ANDREW R. AANDAHL, WILLIAM G. MURRAY *and* WAYNE SCHOLTES, *Journal of Farm Economics, Vol. XXXVI, No. 3, August 1954.*

The authors (Soil Scientist, Soil Conservation Service; Professor of Economics, Iowa State College; and Associate Professor of Soils, Iowa State College, respectively) point out that research in tax assessment of farmlands has indicated striking inequalities. However, the authors believe that an excellent opportunity exists to use new information on soils, plant growth, and economics for the improvement of tax assessments.

The assessor of Allamakee County, Iowa, Mr. A. L. Hansmeier, provided an opportunity to improve assessments by asking assistance from the Iowa Agricultural Experiment Station in using the new county soil survey in the reassessment he was making of the county. The authors designed a method, including economic classification and ratings, which was used by the assessor in making the reassessment.

The article states that the permissible range of soil characteristics within a soil type or phase is now sufficiently narrowed in most instances to make rather precise predictions. Also, estimates of crop yields for a soil type or phase under defined set of soil management practices are now fairly accurate.

It is pointed out that the extent to which soil maps can be used for assessing land depends upon both the detail and the quality of the classification and of the mapping. If these are adequate, a first approximation of the value of any specific tract of land can be made directly from the maps. It needs to be adjusted for other factors, particularly those related to location, such as schools and roads, and factors such as flood hazard.

The general approach for using soil maps for tax assessments is:

"1. Economic ratings are prepared for each mapping unit or combination of similar units shown on the soil maps.
"2. If ratings are prepared for more than one land use, the land is classified into the different uses such as pasture and cropland.
"3. For each tract assessed separately, the acres of each combination of soil mapping unit and land use are measured and recorded.
"4. Using these acreages as weights, an average rating for each tract is calculated.
"5. Average ratings for individual tracts are converted to assessed dollar values by multiplying by some constant.
"6. The assessed dollar values are adjusted for the other factors not included in the rating."

The authors prepared economic ratings for cropland, permanent pasture, and timber. For each soil, they estimated the net income on the basis of the most likely physical production and costs. The highest net income was given a rating of 100 percent and the net income of the other soils compared with it. They prepared the economic rating for crops as follows:

"1. Estimation of physical production.
  "a. Estimation of 'most likely' or average soil management for each soil used for crops.
  "b. Predictions of the average yield for each crop on the basis of the above set of soil management practices.
"2. Conversion of physical production into net income.
  "a. Prediction of future prices and calculations of gross income.
  "b. Estimation of cropping expenses and calculation of net income.
  "3. Conversion of net income into percentage rating."

The steps used in preparing the economic rating for permanent pasture were:

"1. Estimation of the relative grass production of each soil mapping unit in such terms as cow-days per acre.
"2. Estimation of the ratio between the economic rating for crops and the cow-days per acre at the 'Balance Point.'
"3. Conversion of cow-days per acre into economic ratings by use of the 'Balance Point' ratio.

"Crop and pasture economic ratings can be tied together by noting the kinds of soil on which the farmer finds it difficult to decide whether to put the land into crop or into pasture. The net returns from these soils according to the farmer's best judgment are equal for both uses. These soils are at or near the 'Balance Point'."

The economic rating for timber is prepared by estimation of physical yield, selecting a price, and conversion to an economic rating.

In preparing the economic ratings for Allamakee County, it was found that the spread between the crop, pasture, and timber ratings was great on the more productive soils; but on the less productive soils, the spread narrows. At the "Balance Point" the crop and pasture ratings are the same. The authors state that the general relationship between the different uses can be noted in Table 1, and the soils represent the range of conditions in Allamakee County.

**Table 1. Economic Ratings for Crops, Pasture and Timber for 7 Soils in Allamakee County, Iowa**

| Soil | Slope % | Economic Rating | | |
|---|---|---|---|---|
| | | Crop | Pasture | Timber |
| Judson | 1-6 | 100 | 39 | — |
| Downs-Tama | 4-7 | 77 | 36 | 10 |
| Fayette | 4-7 | 57 | 28 | 10 |
| Fayette | 8-14 | 42 | 22 | 10 |
| Quandahl | 13-16 | 20 | 20 | 9 |
| Stony land | 18-30 | — | 11 | 5 |
| Stone land | 30-60 | — | 1 | 1 |

The authors point out that the final assessed value placed on each tract of land by a county assessor represents his best judgment; and, in the end, it is his decision. The soil maps and the economic ratings, however, should help the assessor to improve his opinion of the value. It is stated, "The procedure outlined here should not be considered as an infallible mechanical process, but rather as one which provides the assessor with a first approximation of the value or an estimate of the earning capacity of the land."

The authors are modest in their appraisal of the method they designed and its potential value to assessors in removing inequalities in tax assessment of farmlands. A comparison of assessment-sales ratios for Allamakee County, Iowa, before and after the reassessment using the authors' methods shows a big improvement in the assessment. The principles of the authors' method have general application, and a decided improvement in assessments can be obtained through their use.

—E. L. SAUER, *Champaign, Illinois*

**PLANTING THE SOUTHERN PINES.** By PHILIP C. WAKELEY, *Agricultural Monograph No. 18, Forest Service, U.S.D.A. Superintendent of Documents, Government Printing Office, Washington, D. C. 236 pages, illustrated. 1954. $2.75.*

Much of the information contained in this publication is drawn from studies conducted by the Forest Service at its Southern Experiment Station in New Orleans and from records of its southern region at Atlanta, Georgia. Many of the conclusions are being published for the first time. Studies and observations cited from other sources have not previously been included in one publication.

Although tree planting in the South has increased tremendously since World War II, the foresters say only about one-tenth the whole job has been accomplished. They estimate some 13 million acres are still in need of planting in order to maintain timber supplies or to control soil erosion.

The publication discusses everything about planting southern pines from selecting the species that will best grow on a particular piece of land to protecting the growing tree from insects, disease and fire. It explains when to plant trees and how—the spacing, preparation of the ground, and tools to use. The care of seeds is discussed from the gathering through the cleaning, drying and storage to actual germination.

It concludes with instruction on care of pine plantations. The control of injuries caused by fire, climate, soil, animals and insects is discussed, along with the thinning and pruning methods and procedures that will insure maximum usable volume growth and rapid tree development. The fertilizing and cultivation of plantations is touched on briefly.

For those planning to set up their own nursery or raise seedlings for distribution, the publication gives details on how to go about it. It also tells where people planting seedlings can buy their stock.

**APPLIED FOREST MANAGEMENT.** By PAUL E. BRUNS, *Associate Professor of Forestry, Montana State University. 383 pp. Lithoprinted Edwards Bros., Ann Arbor, 1954. Available only from author at 119 Mount Ave., Missoula, Montana. $5.00.*

This book by a former industrial forester regards wood production as a use of forested land, but not necessarily the primary use. It is written from the view-

point of the forest land manager, putting "first things first" as problems such as taxation, logging economics, inventories and forest roads are given detailed development. In a chapter on young growth timber management the author draws on practical European and native experience in the maintenance of forest soil productivity.

There is a discussion on business aspects of management followed by an entire chapter on forest land use coordination. The chapter develops in turn the interrelationships of grazing, wildlife, recreation and water to wood production and to each other. The forest manager must classify his forested land as to a dominant use. The secondary uses are then subordinate and can be developed only insofar as they do not hamper attainment of the highest practical yield of the dominant use.

**Human Adjustment to Floods.** By GILBERT F. WHITE, *Department of Geography, University of Chicago, Chicago 37, Ill. 1945. $3.00.*

The material in this book was obtained from reviews of federal and private reports on floods. It covers, among other items, the responses to floods by the public, concepts of floods, attitudes of flood correction, the natural and social factors which have been important in the occupancy of flood plains, and human adjustments to flood hazards. Some of the conclusions are far-reaching in scope—especially those that pertain to the human factor.

Conservationists and others working in the watershed development field will find the author's views stimulating as well as thought-provoking.

**Biological Conservation.** By JOHN D. BLACK. *The Blakiston Company, New York. 328 pages, illustrated. 1954. $5.00.*

This book is intended for college students desiring to seek a basic understanding of the science and practice of wildlife management. It also includes an excellent presentation of the relationship of wildlife to soils, water, forests and other resources. The manner in which the material is written along with the many fine illustrations should create more than usual interest in the subject.

An important feature of the book is a long list of references and an outstanding directory of films. This material gives added emphasis to the various phases discussed in the book.

**Plant Regulators in Agriculture.** EDITED BY HAROLD B. TUKEY. *John Wiley & Sons, Inc. New York. 269 pages. 1954. $5.50.*

This book, edited by Harold B. Tukey, brings together under one cover the specialized knowledge of seventeen authorities working in the field. The authors clarify the nature of plant regulators, how well they work, explain the chemistry involved, describe plant response, and give details about their specific treatment and usefulness.

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**Ernest Thompson Seton's America.** *Edited by* FARIDA A. WILEY, *Devin-Adair Book Co., New York. 242 pages. $5.00.*

A fascinating book! Miss Wiley has done a superb job in bringing together the dramatic stories of this great naturalist including his field observations on nature, the lives of game animals and experiences encountered on field trips. The book also contains an excellent selection of campfire legends and many very fine drawings pertaining to outdoor life.

**Engineering for Agricultural Drainage.** By HARRY B. ROE AND QUINCY B. AYRES. (*First Edition*) *McGraw-Hill Book Company, 330 W. 42nd Street, New York. 501 pages, illustrated. 1954. $7.50.*

Conservationists confronted with drainage problems will find this new book extremely valuable. It brings together a great deal of information on drainage in one publication which heretofore was available only in separate publications. The book also contains up-to-date new drainage material.

Subjects covered in the book include Soils in Relation to Drainage, Water Properties of Soils, Major Types of Drains and Drainage Problems, Underdrains, Drain Tiles, Drainage of Irrigated Lands, Cost of Drainage and others equally important.

**Leaders in American Science** (*First Edition*) EDITED BY ROBERT C. COOK. *110 Seventh Avenue, North Nashville, Tennessee. 852 pages. 1953-1954. $12.00.*

An important feature of this book is the up-to-date list of outstanding scientists in private industry, government and colleges and universities. It covers every specialized scientific field. Unfortunately, however, some of the more outstanding leaders in the conservation movement are not listed.

The book lists more than 13,500 Leaders in American Science—each followed by a sketch containing information not usually available in biographical directories. Workers in research—both public and private—will find this book useful as a reference.

### Conservation Books for Young People

**The First Book of Conservation.** *By* F. C. SMITH, *illustrated by* RENE MARTIN. *Franklin Watts, Inc., 699 Madison Avenue, New York 21, New York. 70 pages. $1.75. 1954.*

An outstanding book about natural resources — what they are, what they mean to us, how we have sometimes damaged them, what we are now doing to conserve and renew them.

**Trouble at Beaver Dam.** *By* FLORENCE MATTHEWS TCHAIKA. *Illustrated by* FEODOR ROJANKOVSKY *and edited by* ROSE WYLER. *Julian Messner, Inc., 8 West 40th Street, New York 18, New York. 62 pages. $1.60. 1953.*

An everyday science story. Dramatizes the importance of wildlife conservation. Exciting, easy-to-read book for children 7 to 11 years of age.

**Oliver Becomes a Weatherman.** *By* JACK BECHDOLT. *Illustrated by* RALPH RAMSTAD *and edited by* ROSE WYLER. *Julian Messner, Inc., 8 West 40th Street, New York18, New York. 63 pages. $1.60. 1953.*

A hilarious everyday science story about a home weather bureau. It answers children's 'why' and 'how' questions in an entertaining way. For grades four to six.

**Make Way for Water.** *By* ELEANOR CYLMER. *Illustrated by* J. C. WONSITLER. *Julian Messner, Inc., 8 West 40th Street, New York 18, New York. 63 pages. $1.60. 1953.*

In a dramatic story, full of exciting situations, the author tells how a big city is supplied with water, explains the workings of reservoirs and the functions of the Department of Water Supply.

**All About the Weather.** *By* IVAN RAY TANNEHILL. *Illustrated by* RENE MARTIN. *Random House, Inc., 457 Madison Avenue, New York 22, New York. 144 pages. $1.95. 1953.*

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## Wind Erodibility of Field Surfaces

(*Continued from page 265*)


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# Field Notes and Comments

## Michigan Resources Conference

The Michigan Resources Conference, outgrowth of the national Resources for the Future conference in Washington last December, is scheduled for Lansing, Michigan, January 11-12, 1955.

Resource problems and recommendations for their solutions will be divided into six sections: Water, land, forest, recreation, minerals, fish and wildlife. The sessions will be held in the Olds Hotel.

The conference will be sponsored cooperatively by Michigan State College, University of Michigan and the Michigan School of Mining and Technology. A steering committee to direct the conference is comprised of Paul A. Herbert, Stanley Fontanna and J. Murray Riddell.

Dr. R. G. Gustavson, national director of Resources for the Future, will keynote the conference, discussing *"Resource Problems of the United States"*. The second principal address will be made by Dean S. T. Dana, Dean Emeritus, of the University of Michigan on the subject *"Resource Problems of Michigan"*.

## Second Annual Nash Conservation Awards Program Now in Progress

George W. Mason, president of American Motors Corporation, recently announced that winners in the second annual $5,000 Nash Conservation Awards Program will be announced early in January. Ten professional and 10 non-professional awards will be made.

Each of the ten awards to professional conservation workers consists of $500 and a bronze plaque designed by Robert Weinman, noted sculptor. Persons working in all fields of conservation—administration, education, research, or law enforcement—are eligible. Ten additional awards consisting of a mounted bronze plaque will be made to non-professionals.

"The automobile industry has a large stake in the furtherance of public recognition of the importance of conservation," Mason said. "It is the purpose of this program to call public attention to conservation workers whose efforts do not ordinarily receive public notice. Therefore, those who are chosen to receive Nash Conservation Awards are selected as typifying various phases of conservation activity, rather than as being necessarily the top men in these fields. In fact, when a man has already received wide public-recognition, we feel it behooves us to name someone less well-known. In this way, we hope to increase public understanding and recognition of the complexity and diversity of modern, scientific conservation practice."

The 1954 awards will be presented at local dinners to be held in the home communities of the persons receiving awards, Mason announced. The awards program was inaugurated last year with a banquet in Washington attended by many congressional leaders and high-ranking officials of Federal and private conservation agencies.

Instead of utilizing the printed nomination forms of last year's program, nominations will be accepted in the form of letters or recommendations. Only professional conservation workers are eligible to make nominations for the professional awards, and nominations should be addressed to Ed Zern, Director, Nash Conservation Awards Program, Room 1700, 745 Fifth Avenue, New York 22, New York.

Nominations will be accepted until December 1, and announcement of those receiving awards is expected to be made on January 15, 1955.

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Under the new tax code, expenses for soil and water conservation practices incurred by farmers may be deducted, up to 25 per cent of gross income derived from farming in any year. Expenses over 25 per cent may be carried over to the next year and to succeeding years. Allowable expenses cover land levelling, grading, terracing, contour furrowing, water diversion, drainage, water course protection, brush removal and the planting of windbreaks.

## Helpful Booklets from Advertisers

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- ☐ **PIONEERS OF PROGRESS;** 32 pages, a cartoon history of agriculture in America from 1620 to today. Minneapolis-Moline Company, Minneapolis, Minnesota.
- ☐ **FUN ON THE FARM;** a 24 page coloring book of farm scenes for children. Minneapolis-Moline Company, Minneapolis, Minnesota.
- ☐ **U. S. FOOD FACTORY;** a 48 page booklet showing how population increase puts pressure on farmers and ranchers for more production. Covers all phases of conservation, illustrated. International Harvester Company, Chicago, Illinois.
- ☐ **MAKING PAYDIRT LAST;** 16 pages, illustrated, covering the subject of practical conservation methods for all acreages whether large or small. It shows how

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☐ **ONE EQUALS FOUR (PASTURE MANAGEMENT)**; a treatise on modern methods for permanent pasture lands in the eastern half of the United States and Canada. J. I. Case Company, Racine, Wisconsin.

☐ **LAND OF PLENTY**; An excellent and well illustrated historical portrayal of the contribution made by the farm equipment industry in farm mechanization. Farm Equipment Institute, 608 South Dearborn Street, Chicago 5, Illinois.

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☐ **TRIED AND NEW IDEAS FOR HANDLING BARNYARD MANURE**; 18 pages illustrated; a thorough but compact booklet on profitable ways of handling barnyard manure. New Idea Farm Equipment Co., Coldwater, Ohio.

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☐ **MARCHING AHEAD WITH CORN**; 24 pages illustrated; the history, present role and future of a vital crop. New Idea Farm Equipment Co., Coldwater, Ohio.

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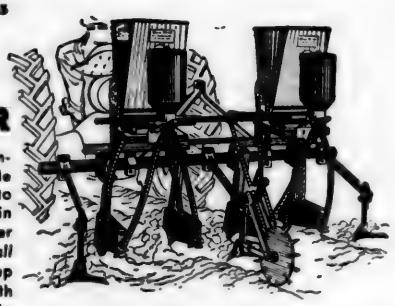

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## SOME NEW INDUSTRY PRODUCTS

### New Ferguson Subsoiler—Pipe and Cable Layer

This revolutionary new Ferguson tool has been designed for double use: (1) as a rugged, low-cost Subsoiler for breaking up moisture-resistant *"hardpan"*; and (2) as a time and money-saving flexible pipe and cable layer for installing underground water and electric lines. The conversion is made in a few minutes.

The Subsoiler is easily converted to Pipe and Cable Layer in a few moments by (1) Bolting a guide tube assembly to the Subsoiler beam; (2) Bolting guide rings to the front and rear of the tractor. To lay flexible pipe or cable, an exploratory subsoiling pass is first made over the route of the line, to reveal any rocks or roots which may be present. Then the length of pipe or cable is laid out alongside the cut. Next the Subsoiler is converted to Pipe and Cable Layer by attaching the guide tube and rings.

At the beginning of the route, the pipe or cable is then threaded through the front guide ring, rear guide ring, and guide tube attached to the Subsoiler. As the tractor is driven forward and the Subsoiler goes into the ground, the piping or cable slips through the guides automatically and is deposited at the bottom of the subsoil cut. Speeds of as high as 300 feet per minute are practical.

### New Rain Bird Sprinklers

The new model sprinklers are being introduced by National Rain Bird Sales & Engineering Corporation of Azusa, California.

*Rain Bird No. 30*

The No. 30 Rain Bird is an innovation in two-nozzle sprinklers. It has the same rugged construction as the No. 30 W announced six months ago which has had outstanding acceptance for use in windy areas and on abrasive water. The addition of a spreader nozzle on the No. 30 increases sprinkler efficiency and assures users of long, satisfactory service even under the most extreme irrigation conditions.

A companion model to this sprinkler is the No. 35 sprinkler which operates on a part or full circle. Recommended for use on lateral ends to keep water off roads during irrigation periods, the No. 35 replaces the former Rain Bird Model No. 45. Constructed with less moving parts than the previous model, it offers longer, trouble-free service and more advanced irrigation techniques.

## Soil Survey Committee Formed

A Joint Policy Committee on the National Cooperative Soil Survey has been established by the Association of Land Grant Colleges and Universities and the U. S. Department of Agriculture.

The stated purpose of the committee is the formulation of policies to strengthen the survey and to bring about even closer cooperation between the Department and the State Colleges and Universities.

Responsibility for the scientific survey and classification of the Nation's soils was assigned in 1952 to the Soil Conservation Service. Speeding up this work and completing the national land inventory is considered important not only to the development of soil conservation programs on individual farms and ranches, but also to watershed development, to the research programs of the Department of Agriculture, to the State agricultural colleges, and to the action programs of all agencies concerned with land use.

Members of the Joint Committee include:

For the Association of Land Grant Colleges and Universities: Dr. R. H. Walker, Director, Utah State Agricultural Experiment Station; Dr. G. M. Browning, Associate Director, Iowa State Agricultural Experiment Station; Dr. R. W. Cummings, Director of Research, North Carolina State Agricultural Experiment Station; and P. R. Miller, Associate Director, Vermont Agricultural Experiment Station.

For the Department of Agriculture: J. Earl Coke, Assistant Secretary of Agriculture; D. A. Williams, Administrator, Soil Conservation Service; Dr. Charles E. Kellogg, Assistant Administrator for Soil Survey, Soil Conservation Service; and Dr. Robert M. Salter, Chief, Soil and Water Conservation Branch, Agricultural Research Service.

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## Efficiency in Agriculture

"Farming efficiency is many things. It is crops and soils, methods and men. It is machines and electric power. It is the use of adapted plant and seed varieties that will produce big yields and high quality crops. It is good rotations to help maintain and build soil fertility. It is protecting the land against erosion. And it is the wise use of plant food, of fertilizers, of crop residues, of lime and other soil building aids."

—Ezra T. Benson,
*Secretary of Agriculture.*


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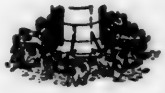
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# 'We Have No Erosion. Our Land Is Level'

How often you've heard someone say that! It raises a question of who's kidding whom.

*How about* run-off? Put enough water on "level" land, and it will run somewhere. And when it runs, look out! Flatlands are not damageproof against moving water. (See picture.)

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*How about* soil structure? Beating rains can destroy the desirable granular structure of a soil. They pack the soil—hard and tight.

*How about* puddling, flood water, or standing water? Too much water can be as bad as not enough, and surplus water usually finds its way down from the higher land—to the "flat" bottoms.

*How about* wind erosion? It's no respecter of level land either.

*How about* loss of seed, fertilizer, organic matter? Water can carry it away from level land, too.

No erosion on "level" land? Don't kid yourself! No matter what your topography may be, you must be constantly alert to the needs of soil maintenance.

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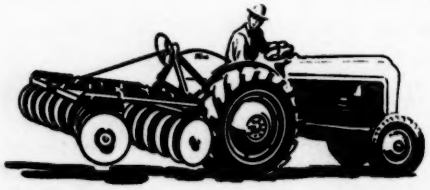

*The Dearborn Adjusto-Flex Harrow is raised, lowered and depth-controlled by Ford Tractor hydraulic power. Discs "ride" to and from the field . . . turns at point rows and headlands are made without dirt ridging . . . grassed waterways can be crossed safely and without stopping.*

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